DOCUMENT RESUME

ED 266 008 SE 046 385

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TITLE General Biology Syllabus.
INSTITUTION New York State Education Dept., Albany. Bureau of Curriculum Development.
REPORT NO 85-7438
PUB DATE 86
NOTE 82p.
PUB TYPE Guides - Classroom Use - Guides (For Teachers) (052)

EDRS PRICE MF01/PC04 Plus Postage.
DESCRIPTORS *Biology; Classification; *Course Descriptions; *Ecology; Evolution; *Genetics; High Schools; *Human Body; Physiology; Reproduction (Biology); Science Education; Science Instruction; *Secondary School Science
IDENTIFIERS New York

ABSTRACT

This syllabus has been developed as an alternative to Regents biology and is intended for the average student who could benefit from an introductory biology course. It is divided into seven major units dealing with, respectively: (1) similarities among living things; (2) human biology (focusing on nutrition, transport, respiration, excretion, and regulation); (3) variety among living things; (4) reproduction and development; (5) genetics; (6) evolution and classification; and (7) living things and their environment (with attention to ecology, relationships in the environment, the human population, and human impact on the environment). Each unit includes: a brief introduction; list of objectives; understandings (basic information subject to testing); activities and teacher notes corresponding to the understandings (with suggested laboratory experiences, questions, demonstrations, topics for discussion, career choices, methods of presentation, and references to other portions of the syllabus); and content. General information about the syllabus is provided in an introduction. (JN)

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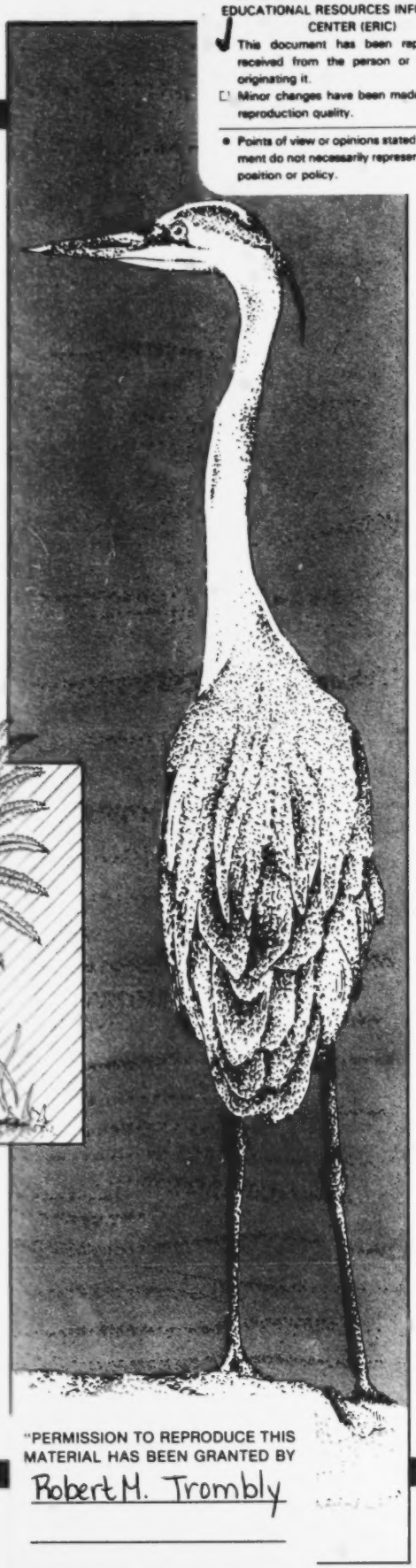

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FOREWORD

This edition of the *General Biology Syllabus* represents a substantial revision of format and content. The field test of the draft copy of this syllabus was conducted during the 1984-85 school year. Participating schools and teachers who provided valuable feedback during the pilot testing were: **Neil Infante** and **Debra Trawinski**, Frontier Central High School; **David Brest, Bernard Dolan,** and **John Wolfrum**, Lakeshore Central High School; **Robert Olsen**, Lindenhurst Senior High School; **Dolores Scanlon**, Lafayette High School; **Sam Capiello**, Minerva Deland School; **Patricia Baker**, Fairport High School; **Thomas Watthews** and **Roberta Rice**, Bethlehem Central High School; **Ingrid Wisniewski,** William Cullen Bryant High School; **Ted Levine** and **Kevin Sheehy**, Tottenville High School; **Michael Kessler, Kenneth Pearsall,** and **Thomas Galbally**, Auburn High School. The fieldtest program was coordinated by **Edwin O'Reilly**, Frontier Central School, Frontier.

As with the syllabuses for general chemistry and general physics, this course is designed for nonscience majors who would benefit from a senior high school science course. *This course may NOT be used for Regents credit towards the Regents diploma.*

This syllabus was prepared by **Scott Hunter**, Schodack Central Schools and **Thomas Watthews**, Bethlehem Central Schools. Members of the General Biology Advisory Committee were **Arline Blecher**, Long Island City High School, **Ann D. Muehleck**, Colonie Central Schools, **Edwin O'Reilly**, Frontier Central Schools, and **Robert Werner**, George Washington High School, New York. **Ann Muehleck** and **Douglas Frank**, South Colonie Central Schools, reviewed the manuscript. **Dr. Wayne Moyer,** former executive director, National Association for Biology Teachers, also reviewed the manuscript. **Margaret Ann Hasselwander** aided in the production of the manuscript.

Thomas A. Boehm, Associate, Bureau of Science Education and **Barry W. Jamason**, Associate, Bureau of Curriculum Development coordinated the development of this draft and prepared it for distribution.

CONTENTS AND TOPIC OUTLINE

PAGE

FOREWORD iii

INTRODUCTION 1

UNIT 1 – SIMILARITIES AMONG LIVING THINGS 3

I. **Definition of Life** 4

II. **The Cell as a Common Unit** 4

A. Cell Study 4

1 Compound light microscope
2 Staining techniques
3 Dissecting microscope
4 Centrifuge

B. Cell Structures 5

1. Organelles common to animal and plant cells
2. Organelles specific to plant life
3. Organelles specific to animal life

C. Cell Functions 7

1. Nutrition
2. Transport
3. Respiration
4. Excretion
5. Regulation
6. Reproduction
7. Synthesis

D. Cell Specialization 9

III. **ORGANIZATION OF LIVING SYSTEMS** 9

A. Tissues 9

B. Organs 10

C. Organ Systems 10

D. Organism 10

UNIT 2 – HUMAN BIOLOGY 11

I. **Nutrition** 12

A. The Need for Food 12

1. Foods and nutrients
2. The caloric value of foods
3. The need for a balanced diet

B. Ingestion of Foods 13

PAGE

C. Digestion 14
1. The digestive system
2. The end products of digestion

D. Egestion 15

E. Digestive System Disorders 15

II. Transport 15

A. Absorption 15

B. Circulation 16
1. The circulation (transport) system
2. Pathways of circulation

C. Transport System Disorders 19

III. Respiration 19

A. Breathing 19
B. Cellular Respiration 19
1. The respiratory (breathing) system
2. Control of breathing rate

C. Respiratory System Disorders 20

IV. Excretion 20

A. Major Metabolic Wastes 21

B. The Role of Blood in Excretion 21

C. The Excretory System 21
1. Skin
2. Lungs
3. Urinary system

D. Excretory System Disorders 22

V. Regulation 22

A. Nerve Regulation 22
1. The nervous system
2. Types of behavior
3. Nervous system disorders

B. Chemical Regulation 24
1. The endocrine system
2. Examples of hormonal action
3. Endocrine system disorders

VI. Movement and Structural Support (Muscles and Skeleton) 25

A. Advantages of Locomotion 25

PAGE

B. Structures Involving Locomotion 25
1. Bones, cartilage, and joints
2. Muscles
3. Tendons and ligaments

C. Muscle Action 26

D. Muscle Function (Involuntary/Voluntary) 26

E. Muscle – Bone Disorders 27

UNIT 3 – VARIETY AMONG LIVING THINGS 28

I. Some Simple Organisms 29

A. Viruses 29

B. Bacteria 29

C. Fungi 31

D. Algae 32

E. Protozoa 33

II. Complex Organisms 33

A. Plants 34
1. General characteristics
2. The role of plants as producers
3. Major plant divisions
4. Economic uses of plants (plant products)

B. Animals 37
1. General characteristics
2. The role of animals as producers
3. Major animal divisions
4. Economic uses of animal (animal products)

UNIT 4 – CONTINUATION OF LIFE: REPRODUCTION AND DEVELOPMENT .. 38

I. Reproduction as a Life Function 39

A. Reproduction and Cell Division 39

B. Reproduction and Species Survival 39

C. Types of Reproduction 39

II. Sexual Reproduction 39

A. Sexual Reproduction in Animals 39
1. Sex cells
2. Specialized reproductive systems
3. Reproductive system function
4. Animal growth
5. Human reproductive disorders

PAGE

B. Sexual Reproduction in Flowering Plants 42
1. Sex cells
2. Flower structure
3. Flower function
4. Seed dispersal
5. Seed germination
6. Plant growth

III. Asexual Reproduction 43

A. Asexual Reproduction in Unicellular Organisms 43

B. Asexual Reproduction in Animals 43
1. Budding
2. Regeneration

C. Asexual Reproduction in Plants 44
1. Vegetative propagation
2. Spore formation

UNIT 5 – CONTINUATION OF LIFE: GENETICS 45

I. Genetics 46

II. Reproductive Basis for Genetics 46

A. Inherited Traits 46

B. Assurance of Genetic Continuity 46
1. Species and chromosome number
2. Mitosis
3. Meiosis
4. Fertilization

III. Foundations of Genetics 48

A. Chemical Genetic Studies 48

B. Gene-Chromosome Concept 48
1. Chromosomes and genes
2. Gene inheritance

IV. Genetic Patterns 48

A. Dominance/Recessiveness 49
1. Definition
2. Examples of dominance

B. Sex Inheritance and Sex Linkage 50
1. Definition
2. Examples of sex-linked inheritance

C. Other Patterns of Inheritance 51

V. Genetic Patterns and the Environment 51

PAGE

VI. Chemical Basis for Genetics 51

A. Genes 51
1. Structure of DNA
2. Function of DNA

B. Changes in Genetic Information 52
1. Mutations
2. Mutagenic agents

C. Genetic Engineering 52
1. Definition
2. Benefits/drawbacks
3. Examples

UNIT 6 – EVOLUTION AND CLASSIFICATION 54

I. Organic Evolution 55

A. Origin of Life 55
1. Age of the earth
2. First living things

B. Supporting Evidence of Evolutionary Theory 56
1. Comparison of skeletons
2. Comparison of embryos
3. Comparison of cells
4. Comparison of chemicals in living things
5. Presence of vestigial structures
6. Study of fossils

C. Early Theories of Evolution 57
1. Lamarck's theory
2. Darwin's theory of natural selection

D. Modern Theories 58
1. Mutations
2. Sexual reproduction
3. Geographic isolation

E. Human Evolution 59
1. Problems in studying human evolution
2. Characteristics unique to humans
3. Future of human evolution

II. Classification 60

A. The Need for a Classification System 60

B. Basis for Classification 60

PAGE

C. Classification Groups 61
1. Kingdom
2. Phylum
3. Class
4. Genus
5. Species

D. Scientific Names vs. Common Names 62

E. Human Classification 62

UNIT 7 – LIVING THINGS AND THEIR ENVIRONMENT 63

I. Ecology 64

II. Relationships in the Environment 64

A. Ecosystems 64
1. Living factors in the ecosystem
2. Nonliving factors in the ecosystem

B. Communities 65
1. Interactions in a community
2. Community dynamics

C. Populations 67
1. Interaction within a population
2. Population dynamics

III. The Human Population 68

A. Our Requirements as Individuals 68

B. Requirements of Species 68
1. Interaction with other life forms
2. Interaction with nonliving factors

C. Population Growth 69
1. History
2. Implications

IV. Human Impact on the Environment 70

A. Environmental Pollution 70
1. Water pollution
2. Air pollution
3. Soil pollution

B. Improving the Environment 71
1. Education
2. Research
3. Laws
4. Conservation

INTRODUCTION

Organization. The syllabus has been divided into seven major units. (See Contents, page iv.) The material in each unit is organized as follows:

Understandings. This is the basic information that is subject to testing. The vocabulary used in this column is at the student's level of comprehension.

Activities and Teacher Notes. Under this heading are the suggested student laboratory experiences, questions (*in italics*), demonstrations, topics for discussion, career choices, suggested methods of presentation (denoted by a bullet) and teacher references to other portions of the syllabus. *Items in this column that directly support the understandings are subject to testing.*

Objectives. Objectives are included at the beginning of each unit.

Content. An effort has been made to make the syllabus content reflect recent discoveries, theories, and trends in the biological sciences. In addition, the pogram is designed to allow flexibility in the selection of course content. Teachers are encouraged to use this latitude to design a course commensurate with the needs and background of their students.

Audience. This syllabus has been developed as an alternative to Regents biology and is intended for the average student who could benefit from an introductory biology course. In addition to developing biology courses based on this syllabus and the Regents Biology Syllabus, some schools may need to develop their own local biology course for students with different needs.

Diploma Credit. The course based on this syllabus may be used as an elective for a local diploma, as part of a sequence for a local diploma, or as part of the minimum required science credit toward a local diploma.

This course may NOT be used for Regents credit towards the Regents diploma.

Careers. Where appropriate, careers related to the type of content being discussed are noted in the right-hand column. Discuss these career opportunities with the students.

Sequencing and Scheduling. Six 40-minute periods a week for a full school year is the minimum time recommended for this course.

The format of this syllabus is designed to provide a series of options for students of different ability levels. Teachers are encouraged to consider the following when developing their course of study.

Students are required to complete:

Unit 1 – Similarities and Differences Among Living Things

Unit 2 – Human Biology

Unit 7 – Living Things and Their Environment

and two (2) of the remaining four units (Units 3, 4, 5 and 6).

This flexibility permits teachers to emphasize different themes through the selection of optional units. This requirement is effective from September 1986.*

Laboratory Requirements. It is strongly recommended that the general biology course be taught in a laboratory classroom and include a regularly scheduled laboratory period. The laboratory experience in general biology should provide hands-on experiences which show the application of concepts developed in the classroom.

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* For the school year 1985-86 only, Unit 1 and Unit 2 will be required and Unit 7 will be an optional unit. The June 1986 exam will reflect this.

Laboratory Evaluation. As part of their preparation for the State examination in general biology, students should develop the following laboratory skills:

1. *Measurement* – using and reading instruments such as metric rulers, centigrade thermometers, and graduated cylinders.
2. *Microscope* – using and caring for a microscope; identifying cell parts such as the nucleus cell wall, chloroplast, and cytoplasm under the compound microscope.
3. *Slide preparation* – preparing wet-mount slides and staining using iodine or methylene blue.
4. *Indicators* – using indicators such as pH paper, Benedict's, iodine.
5. *Graphing* – interpreting and producing bar and linear graphs.
6. *Dissections* – dissecting flowering plants and invertebrates.
*7. *Laboratory investigations* – using effective problem-solving.
8. *Safety* – developing safety habits in the laboratory.

In addition to the above laboratory skills being evaluated on the State examination, up to 10 points will be earned as part of a locally developed laboratory evaluation program based on these eight skills. The local evaluation should be completed prior to the examination date, scored, and added to the raw examination score. Methods of administering the local laboratory evaluation program should include: laboratory practicals, paper and pencil tests, observations of students working in the laboratory, and laboratory write-ups.

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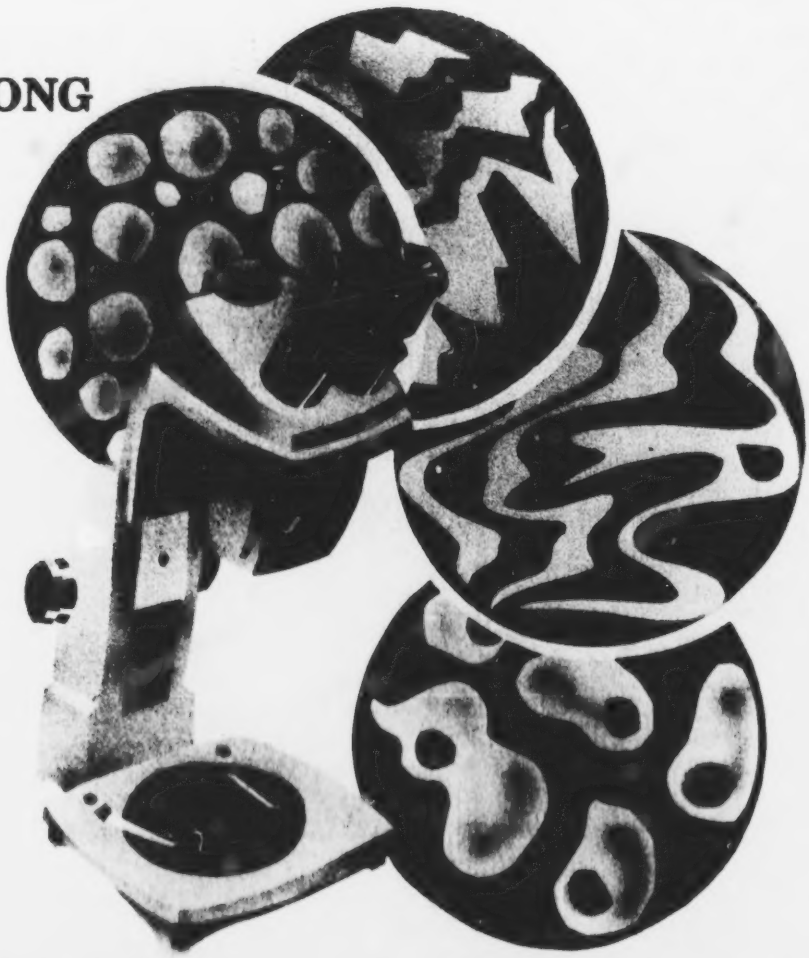
* A suggested problem-solving approach:

Planning	–	develop a testable hypothesis after considering a series of questions related to the problem
Procedure	–	establish a suitable procedure to test the hypothesis (including control(s), variables, observation methods).
Obtaining and Analyzing Data	–	collect data; draw appropriate diagrams and charts to represent data; write accurate observations.
Analyzing Data	–	use the data to identify apparent patterns and relationships and to state inferences.
Generalizing and/or Synthesizing From Data	–	develop conclusions based upon these apparent patterns and relationships and stated inferences.
Decisionmaking	–	decide whether these conclusions support the stated hypothesis.

UNIT 1
SIMILARITIES AMONG LIVING THINGS



INTRODUCTION

Biology is the study of life. This unit introduces some basic concepts in biology that will aid students in their study throughout the general biology course. The concepts of cell structure, cell function, and the organization of living systems are the concepts stressed in this unit.

OBJECTIVES

Upon completion of this unit, the student should be able to:

- Identify the cell as the unit common to living things.
- Describe several functions carried on by cells that promote their survival.
- Identify several cell organelles and describe their functions.
- Describe ways cells can be studied in the laboratory.
- Describe the levels of organization in living things.

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
I. DEFINITION OF LIFE	
Life is characterized by the properties and functions of cells. For the continuation of life, cells must be able to: • Obtain food and digest it (nutrition). • Absorb needed materials from their environments (transport). • Release energy from foods (respiration). • Get rid of wastes (excretion). • Respond to changes in the environment (regulation). • Grow and reproduce new cells (reproduction). • Produce complex substances from simple substances (synthesis).	Ask students to give examples of life activities. *How are living things distinguished from nonliving things?* • Place several specimens at various laboratory stations. Classify them as "living," "nonliving," or as "products of living things."
II. THE CELL AS A COMMON UNIT	
The Cell Theory The cell is a structure common to most living things. It serves as the basic structural and functional unit of life and is the smallest unit that is capable of carrying on life processes.	Mention organisms that are not composed of cells (e. g., virus). Teachers may wish to present the historical development of the cell theory.
A. Cell Study Cells are very small and difficult to study without special instruments. Since Robert Hooke's discovery of cells in the 17th century, many instruments and techniques for studying cells have been developed. Examples include:	*What instruments and techniques may be used to study cells in the laboratory?* • Demonstrate parts and functions of the compound light microscope. Observe a prepared slide of the letter "e" for practice. • Demonstrate proper microscope techniques. Use the microscope as a measuring tool for small objects such as newsprint letters and preserved microorganisms. Measure in metric units. • Observe a living insect with a dissecting microscope. Compare the characteristics of the dissecting microscope with those of the compound light microscope. • Centrifuge a yeast cell suspension to concentrate them for study.
1. Compound light microscope The compound light microscope is frequently used for cell study. It can increase the apparent size of materials making them easier to study. For study with this microscope, the specimen must be thin enough for light to pass through it easily.	Students should be familiar with the parts and functions of the compound light microscope. Mention the electron microscope as a tool of biologists, explaining its advantages and disadvantages.

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
2. Staining techniques Many parts of the cell are almost colorless and are hard to distinguish from other cell parts. Staining techniques have been developed to "color" certain cell parts so that they may be more easily studied with the compound light microscope.	Careers: Lab technician Microscopist Cancer researcher Pathologist
3. Dissecting microscope The dissecting microscope allows study of large specimens that cannot be observed readily with the compound light microscope. The lower magnification and three-dimensional quality is useful in performing dissections.	
4. Centrifuge The centrifuge is used to separate cell parts from each other in order to facilitate further study.	
B. Cell Structures Cells contain smaller structures, known as organelles, which aid the cell in performing its functions. While cells have certain organelles in common, certain cell types contain organelles associated only with that cell type.	*What are the major parts of the cell?* • Observe cheek cells under the high power objective of the microscope. Use methylene blue or iodine to show major organelles. • Observe a variety of cell types with the microscope. • Practice wet-mount slide preparation techniques. • Examine stained and unstained cells with the microscope (i. e. , onion and cheek cells).
1. Organelles common to the cells of most living things Living cells contain:	
a. Plasma membrane The plasma membrane surrounds the cell. It provides a boundary between the cell and its environment and regulates the passage of materials into and out of the cell. Cell membranes are selectively permeable.	The term "plasma membrane" is used to refer to the outer cell membranes. The term "cell membrane" is currently used by cell biologists to refer to the membrane of an organelle. The plasma membrane is covered in more detail under **C. Cell Functions**.
b. Cytoplasm Cytoplasm is the watery cell fluid which contains the other organelles.	Mention the gel state of cytoplasm.
c. Nucleus The nucleus of the cell is surrounded by its own membrane (nuclear membrane) and contains other organelles (chromosomes and nucleoli). It is important in controlling cell activities.	The nucleolus is involved in the production of RNA.

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
d. Chromosomes Chromosomes contain heredity information organized as genes. Genes control cell activities and may be passed to the next generation.	Chromosomes are covered in more detail in **Unit 5 (Genetics)**.
e. Mitochondria Mitochondria are the organelles involved in cellular respiration. They contain the enzymes necessary for the respiratory reactions, and are associated with energy release in the cell.	
f. Ribosomes Ribosomes are involved with the synthesis of proteins in the cell.	
g. Vacuoles Vacuoles are used by the cell to store various materials including water, wastes, and food.	Add to this list of organelles to give students a more complete picture of cell structure (not required).
2. Organelles specific to plant life Plant cells contain:	*What differences exist between plant and animal cells?*
a. Chloroplasts Chloroplasts are the organelles involved in the manufacture of food (photosynthesis). They contain pigments such as chlorophyll and the enzymes (organic catalysts) necessary for food-making reactions.	• Observe *Elodea* cells with the microscope and note the movement of the chloroplasts. Compare these cells to cheek cells. • Observe onion epidermis cells with the microscope. Note the cell walls. Algae may be mentioned as living things which contain chloroplasts and a cell wall, but are not classified as plants.
b. Cell wall The cell wall is a stiff outer cellulose layer which surrounds the cell membrane and its contents. The stiffness of the cell wall limits the growth and movement of plant cells.	The rigidity of most cell walls is due to the presence of cellulose.
3. Organelles specific to animal cells A pair of cylindrical centrioles are located near the nucleus in animal cells. Centrioles are involved in cell division.	Due to the great diversity of life, it often becomes difficult to generalize. In the case of cells with centrioles, there are certain nonanimal cells that contain centrioles, but these are very few in number.

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
C. Cell Functions	
Most living cells carry out the same major activities which are necessary to keep the cell alive. An organism is alive as long as its individual cells are alive and functioning properly.	
Depending on the organism or part of the organism in which they are found, cells may differ in the particular jobs they perform.	
1. Nutrition	
Nutrition includes those activities by which cells obtain food and process it (digestion) to supply energy and materials for the growth and repair of cells.	*How do cells get their foods?* • Observe growths of fungi and describe their destructive action on wood and foods. • Observe paramecia feeding on stained yeast cells. • Grow bean seeds in light and in darkness. Note differences in chlorophyll production and general health of the plants grown under these two conditions. Point out that light is necessary for chlorophyll production.
All animal cells and the cells of certain other organisms (e. g. , fungi) are incapable of making their own food. These cells must obtain their food already formed.	Teachers may wish to use the term "heterotrophic" and/or "autotrophic."
Most plant cells make their own food.	
Photosynthesis is the process by which green plant cells and algae manufacture their own food. It involves a series of complex chemical reactions which use light as an energy source.	
Photosynthesis is an essential process for green plants and algae, since it provides the food needed to keep the cells alive. In addition, the photosynthesis process manufactures food which is used by other living things.	
The process of photosynthesis involves chemical reactions in which carbon dioxide and water (two inorganic substances) are converted into energy-storing compounds (such as sugar) and oxygen gas. Besides light, the process of photosynthesis requires the presence of chlorophyll (the green pigment found in most green plants and algae) and enzymes (organic catalysts) which aid the reaction. Enzymes are necessary for all reactions occurring in the cell.	Students should recognize that organic compounds contain the elements carbon and hydrogen, whereas inorganic compounds do not contain both carbon and hydrogen atoms. Review the functions of catalysts in chemical reactions (not required).
Summary equation for photosynthesis:	

$$\text{carbon dioxide} + \text{water} \xrightarrow[\text{chlorophyll}]{\text{enzymes, light}} \text{sugar} + \text{oxygen} + \text{water}$$

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
2. Transport	
Transport is defined as the life activity in which substances enter and/or leave cells. Transport also includes the circulation of substances throughout a cell or organism. Transported substances include nutrients, oxygen, water, and wastes.	*How Do Materials Enter and Exit The Cell?* • Fill a test tube with water, add three drops of phenolphthalein and cover with a semipermeable membrane. Invert the test tube over a bottle containing a weak solution of ammonium hydroxide. Ammonia gas will penetrate the membrane and cause the phenolphthalein to turn pink, showing that diffusion through a membrane is possible.
The plasma membrane is the part of the cell most directly involved in transport since it is the boundary through which all materials must pass in order to get into or out of the cell.	Detail the structure of the plasma membrane in order to relate its structure with its functions (not required).
Diffusion is a process commonly used by cells to absorb materials. Diffusion involves the movement of molecules from a place of higher to a place of lower concentration.	Osmosis is the diffusion of water across a semipermeable membrane.
3. Respiration	
Respiration is a process by which the energy stored in food is converted to a form which can be directly used by cells. The energy released in respiration is used by the cell to carry on its life processes. Without a constant supply of energy, the cell would die.	*How do cells obtain their energy?* • Measure oxygen intake by germinating seeds or mealworms in a respirometer. • Observe heat energy given off by a burning marshmallow or piece of dried bread.
The two types of respiration carried out by living cells are: • Aerobic respiration, which uses oxygen to aid in the release of energy; • Anaerobic respiration, which does not use oxygen to aid in this energy release.	Mention the role of the mitochondrion in the respiratory process. Contrast the process of fermentation with the aerobic respiration process.
Aerobic respiration releases more energy per molecule of food than anaerobic respiration. Cells of most complex animals and plants use aerobic respiration.	
Summary equation for aerobic respiration:	
$\text{sugar} + \text{oxygen} \xrightarrow{\text{enzymes}} \text{energy} + \text{carbon dioxide} + \text{water}$	
In aerobic respiration, sugar (a food) is chemically broken down and combined with oxygen. Energy is released, and low energy molecules of carbon dioxide and water are produced.	
4. Excretion	
Excretion is the process by which the waste products of other life functions are removed from cells. The process of diffusion is important in the excretion of soluble wastes.	Outline the role of exocytic vesicles (vacuoles) in removing waste from cells.
Products commonly excreted from cells include carbon dioxide and water.	

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
5. Regulation	
Regulation is a process by which cells and/or organisms respond to changes within and around them. As a result, organisms find food, avoid danger, respond to light, and perform other tasks important to their survival. A change in the internal or external environment is known as a stimulus. Some examples of stimuli include light and temperature.	*How do cells sense and respond to their environment?* • Observe examples of stimuli. • Observe cultures of amoebas or paramecia under the compound microscope. Use stimuli such as light intensity, mechanical pressure, weak acid, and salt solutions to induce response.
6. Reproduction	
Reproduction refers to the means by which new cells arise from preexisting cells. Cells reproduce by a process known as cell division which involves a series of changes in the cell leading to the production of two new cells. In organisms made up of many cells, the production of new cells results in growth and in the repair of damaged tissues. While the reproductive process is not necessary to keep individual cells alive, it is essential for the survival of a species.	Cell division is covered in more detail in **Units 4 and 5**.
7. Synthesis	
Synthesis is a process by which cells manufacture complex materials from simpler materials.	
D. Cell Specialization	
Many cells in multicellular organisms are specialized in terms of their structures and functions. Examples of specialized cell types include: • Gland cells – specialized for secretion (production and release of a useful substance); • Muscle cells – specialized for movement; • Nerve cells – specialized for conducting impulses; • Xylem and phloem cells – specialized for conduction of materials in plants.	Details concerning the cell types are given elsewhere in this syllabus. They are included here merely as broad examples of cell specialization.
III. ORGANIZATION OF LIVING SYSTEMS	
Cells are the basic structural and functional units of most living things. In multicellular organisms, they are organized into specialized functional units (tissues, organs, organ systems).	Review the concepts of the Cell Theory here. *How are bodies of living things organized?* • Examine examples of unicellular organisms. • Examine prepared slides of plant and animal tissues. • Examine models, charts, or dissected specimens to show the organization of multicellular living systems.
A. Tissues	
Cells of specialized types are organized into tissues. Each tissue performs one or more functions in an organism.	Give examples of specialized tissues of humans and other organisms.

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
B. Organs	
A group of specialized tissues performing one main function is known as an organ.	Give examples of organs found in the human body (**Unit 2**).
C. Organ Systems	
A group of organs which carry on one of the major body functions is known as an organ system.	Give examples of the major organ systems in the human body (**Unit 2**).
D. Organism	
An organism is made up of organ systems which perform life functions. An organism interacts with other living things in its environment in order to maintain its existence.	A survey of living things is presented in **Unit 3**. Interactions among living things are treated in detail in **Unit 7**.

UNIT 2
HUMAN BIOLOGY

INTRODUCTION

Unit 2 introduces the student to the anatomy and physiology of the human (a vertebrate animal). Human nutrition and various disorders and diseases of the body systems are considered as well as some of the mechanisms involved in the immune response.

OBJECTIVES

Upon completion of the study of this unit, the student should be able to:

- Identify and describe the roles of the nutrients needed to sustain life.
- Recognize the need for a balanced diet.
- Describe some of the structures associated with the digestive, transport, respiratory, excretory, regulatory, muscle, and skeletal systems.
- Explain some of the functions of the various body systems and their components.
- Identify some of the disorders of the body systems.
- Describe the function of the blood as a component of the immune system.

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
I. NUTRITION	
Good health depends upon proper nutrition. Necessary foods must be ingested and processed through the digestive system before they can be absorbed and distributed throughout the body by the transport system. Foods unable to be processed in the digestive tract are passed out of the body during egestion.	*How can vertebrate structures be studied in the laboratory?* • Dissect a preserved frog or some other vertebrate and locate the organs associated with the various body systems. Review the functions of the organs.
A. The Need for Food	
Foods supply the body with the chemicals and energy needed for survival.	Burn a sugar cube dipped in ash or burn a walnut on a pin to demonstrate energy release.
1. Foods and nutrients	
Foods contain six basic nutrients that provide energy and/or chemicals needed by the body to build and repair tissue or regulate body processes. These required nutrients are carbohydrates, fats and oils, proteins, vitamins, minerals, and water.	*How can nutrients be identified in foods?* • Test various foods for nutrients. Use testing reagents such as Benedict's solution, iodine solution, etc.
a. Carbohydrates	
Sugars and starches are the principal kinds of carbohydrates. They provide the main source of energy needed for most activities. Excess carbohydrates are stored as fat or in glycogen (animal starch) in liver and muscle tissue.	Teachers may find it helpful to name the "building blocks" (amino acids, simple sugars, glycerol, fatty acids) of some of the larger nutrient molecules. Knowledge of the chemistry of these molecules is not required.
b. Fats and oils	
Fats and oils also provide energy, yielding more per gram than carbohydrates. They are stored in the body as energy reserves.	
c. Proteins	
Proteins provide organic compounds needed to build tissues. Under circumstances such as starvation, they may be used as an energy source.	The body requires a daily intake of one gram of protein for every two pounds of ideal body weight.
d. Vitamins	
Vitamins are needed to assist the action of certain enzymes. The lack of vitamins results in deficiency diseases.	Discuss vitamin deficiency diseases such as night blindness, beriberi, scurvy, and rickets.
e. Minerals	
Minerals such as calcium, phosphorus, zinc, sodium, iodine, iron, and potassium come from compounds found in various foods. They are used for building body parts and are involved in many functions including nerve and muscle action.	
f. Water	
Water is used to dissolve and transport materials. It makes up the greatest percentage of body weight.	

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
2. The caloric value of foods	
The human body is powered by the energy derived from foods. The energy content of food is measured in a unit of heat known as the Calorie.	A food Calorie = amount of heat needed to raise 1 kg. of water 1° C. The total amount of energy that a food can release is found by completely burning a specific weight of food and measuring the amount of heat energy given off.
Various foods contain different numbers of Calories per gram. Fats usually yield slightly more than twice the number of Calories per gram as carbohydrates and proteins.	Carbohydrates yield 4 Cal./gm. Proteins yield 4 Cal./gm. Fats yield 9 Cal./gm.
The number of calories needed by the body per day depends upon body size, age, sex, climate, and mental and physical activity. More calories are usually needed by larger people, younger people, males, people in cold climates, and active people.	Compare the recommended dietary allowances for infants, children, males, and females. Discuss reasons why nutritional needs vary.
3. The need for a balanced diet	
A balanced diet consists of a selection of foods that provide an adequate supply of energy (Calories) and chemicals. Balanced diets generally contain foods selected from each of the four food groups: meat, vegetable/fruit, milk, and bread/cereal.	*How can you determine if you are maintaining an adequate diet?* • Determine the nutrient composition of some common food items using food composition tables to find the quantity of carbohydrate, protein, fat, vitamins and minerals for each food. • Record all foods eaten during a 24 hour period and evaluate a personal diet by referring to information on recommended number of daily servings, recommended dietary allowances of each food group and caloric values of the foods consumed. Identify any problem with food intake and make recommendations for improvement. • Refer to tables to determine the calories needed during the 24 hour period dependent on height/weight and activities participated in. Compare calorie intake to calories needed, then relate diet to weight loss or gain. Careers: Dietician Food Services
Balanced diets should contain roughage (indigestible vegetable fiber) which helps in the elimination of solid wastes.	Discuss anorexia nervosa, malnutrition, and effects of diets containing food additives (e. g. , MSG, nitrites), saturated fats, excess sugar, and excess salt.
B. Ingestion of Foods	
Ingestion is the intake of food through the mouth. The teeth and tongue assist in ingestion.	

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
C. Digestion Complex foods cannot be used until they are digested. The process of digestion changes these foods into simpler compounds that cells can absorb and use. Digestive enzymes are compounds which bring about the chemical breakdown of foods to simpler substances.	
1. The digestive system The digestive system consists of a continuous tube from the mouth to the anus. Special areas of the tube process the food with the help of secretions from accessory glands and cells lining the tube.	Use a human torso model to identify parts of the digestive system. Students should label a diagram of the digestive system identifying major parts. Emphasize the role of enzymes in digestion. Discuss the specificity of enzymes and the effect of temperature and pH on enzyme activity. Discuss how the acidity or alkalinity of certain parts of the digestive tract influences the action of various digestive enzymes. • Use pH paper and determine pH of acids, bases, various foods, saliva, tap water, and distilled water.
a. Oral cavity The teeth and tongue in the oral cavity aid in breaking up food into small pieces (mechanical digestion). The salivary glands associated with the oral cavity produce saliva which contains an enzyme which begins the breakdown of starch to sugar molecules. Saliva also lubricates food making it easier to swallow.	Teeth types, functions, location, and general structure might be discussed here. The functions of the tongue in tasting and swallowing may be discussed.
b. Esophagus The esophagus is a tube which transports food from the mouth to the stomach by peristalsis. No additional chemical digestion begins in the esophagus. The action of saliva continues in the esophagus until the food reaches the stomach.	
c. Stomach The stomach muscles churn and mix food with gastric fluid secreted by glands in the stomach lining. Gastric fluid contains enzymes which begin the chemical digestion of proteins.	Gastric fluid contains digestive enzymes, water, and hydrochloric acid (HCl). HCl provides the proper pH for enzyme action in the stomach and helps kill bacteria normally present in food.
d. Small intestine Digestion of food is completed in the small intestine. This digestion is accomplished as a result of the action of enzymes produced by intestinal glands and the pancreas. Bile from the liver prepares fats and oils for digestion by enzymes. The end products of digestion pass into blood capillaries or the lymph system, located inside tiny fingerlike projections of the intestinal wall known as villi, primarily by the process of diffusion.	Discuss how the villi increase the surface area of the small intestine for absorption. Compare to "terry cloth."

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
e. Large intestine Undigested foods (wastes) pass from the small intestine into the large intestine. The nonfunctional appendix is located near the region where the small intestine joins the large intestine. Water, some vitamins, and minerals are absorbed from these wastes into the bloodstream. The remaining substances are then stored in the lower end of the large intestine which is known as the rectum.	
f. Accessory digestive structures The salivary glands, liver, and pancreas are accessory glands which produce chemicals which aid in digestion. The gall bladder stores the bile produced by the liver.	Discuss the function of the gall bladder and how bile increases the surface area of fats for chemical digestion by lipases. Bile can be likened to a detergent. Food does not enter the accessory digestive structures.
2. The end products of digestion As complex foods are processed by the mouth, stomach, and small intestine, they are converted to smaller, simpler compounds known as end products which can be absorbed and used by cells. Complex nutrients and their end products of digestion are: • carbohydrates *yield* simple sugars • fats and oils *yield* fatty acids and glycerol • proteins *yield* amino acids	*How can the digestive process be studied in the laboratory?* • Mouth – Observe the effects of salivary amylase on starch. • Stomach – Compare the rate of digestion of large and small pieces of cooked egg white with gastric fluid. Relate surface area to rate of digestion. • Observe the effects of pepsin in an acid solution on protein and compare to pepsin without acid on protein. • Small Intestine – Observe the effects of bile on fats and pancreatic fluid on pieces of egg white (protein).
D. Egestion Materials that are not digested, along with bacteria, mucus, mineral salts, epithelial cells, and metabolic wastes are eliminated from the rectum through an opening known as the anus.	
E. Digestive System Disorders Some disorders of the digestive system include: • Ulcers • Appendicitis • Tooth decay • Diarrhea • Constipation	Explain the symptoms and some of the causes/ treatments of digestive system disorders. Show a diagram of tooth decay.
II. TRANSPORT Transport involves the absorption and distribution (circulation) of materials throughout the body.	
A. Absorption Absorption involves the passage of materials into and out of the bloodstream. Examples of absorption include oxygen diffusing into blood capillaries of the lungs, food	Review the concepts of diffusion presented in **Unit 1**.

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
entering blood in villi, and carbon dioxide diffusing into the blood capillaries of body tissues.	
B. Circulation	
Once materials are absorbed into the blood they are distributed to other parts of the body by the circulatory system.	Discuss William Harvey and his investigation of blood circulation.
1. The circulatory system (Transport system)	
The circulatory system consists of the heart, blood vessels, blood, lymph, and lymph vessels.	
a. Heart	
The heart pumps blood through blood vessels adjusting the rate of flow and pressure to changing body requirements. It consists of four chambers and valves which regulate the direction of blood flow in and out of the heart. Two chambers, the ventricles, pump blood out of the heart, and two chambers, the atria, receive blood and pump it to the ventricles.	Discuss heart transplants and artificial hearts. Do a demonstration dissection of an animal heart or use a heart model and point out the chambers and valves. *How can heart activity be studied?* • Use stethoscopes to listen to the heart. Relate the sounds to the opening and closing of valves.
b. Blood vessels	
Blood vessels are tubes which transport blood to and away from body parts. There are three major types of blood vessels.	• Use a sphygmomanometer and measure blood pressure. • Take pulse rate while at rest. Then take pulse rate after various activities; while seated, when standing, and after running in place.
1) Arteries	
Arteries transport blood under high presure away from the heart. They are muscular and help pump blood. They branch repeatedly and gradually become smaller in diameter.	Use an overhead projector, transparencies, charts, films, and filmstrips to trace the flow of blood through the heart. Discuss the location and functions of the coronary blood vessels. Students should be able to label a heart diagram, identifying chambers, valves, major vessels, and direction of blood flow.
2) Capillaries	
Capillaries are microscopic, thin-walled tubes which connect arteries to veins. Exchange of necessary materials, such as oxygen and carbon dioxide between the blood and body parts takes place through capillary walls. Capillary walls are only one cell in thickness.	Demonstrate circulation in the tail of a goldfish.

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
3) Veins Veins transport blood under low pressure from the capillaries to the heart. The muscular walls of veins are thinner than the walls of arteries. Veins have valves which prevent the backflow of blood.	
c. Blood Blood is the liquid medium which transports materials throughout the body within blood vessels. Components of the blood include:	*What are the characteristics of blood vessels and blood?* • Observe prepared slides of artery and vein cross sections. • Observe a prepared slide of blood. Identify red blood cells, white blood cells, and platelets. Invite a speaker from the American Red Cross to describe the value of blood donations and the uses of blood components.
1) Plasma Plasma is the fluid (mostly water) which transports blood cells and dissolved materials (end products of digestion, hormones, cellular excretions, and antibodies) throughout the body. Plasma also helps to regulate body temperature by distributing excess heat in the blood to body surfaces.	Teachers may wish to discuss blood types, blood typing or blood transfusions.
2) Red blood cells Red blood cells contain the red, iron-containing compound (hemoglobin) which carries oxygen and carbon dioxide. Blood high in oxygen content is termed "oxygenated." Blood low in oxygen content is termed "deoxygenated."	Construct red blood cell models using red, nonsetting clay. Indicate lack of nucleus and where they are produced in the body. Discuss the effect of carbon monoxide in the blood. Careers: Blood Bank Worker Nurse Lab Technician
3) White blood cells White blood cells are part of the immune system and aid in controlling certain diseases by ingesting bacteria. Some white blood cells produce proteins known as antibodies. These antibodies are also part of the immune system and function to protect the body against certain microorganisms. The production of antibodies by white blood cells may be artificially stimulated by a vaccine (vaccination). Antibody production is also stimulated by the presence of microorganisms or other foreign proteins in the body.	Relate the action of the white blood cell to how the amoeba ingests food. Have students discuss experiences with vaccines. Discuss the value of required inoculations for school attendance, travel, armed services, etc. There are five required public school immunizations: Diphtheria – Tetanus Oral Polio (Sabin) Measles Mumps Rubella (German measles) Mention the value of keeping an immunization record.

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
	In addition to antibody production, there are other types of immune responses, e. g. , skin graft rejection and organ transplant rejection.
	Discuss the AIDS (Acquired Immune Deficiency Syndrome) virus and its effect on the immune system.
	Discuss active and passive immunity. Stress the advantages and disadvantages of both types.
	Discuss tetanus antitoxin and why it is recommended when puncture wounds are sustained.
4) Platelets	
Platelets initiate the formation of a blood clot.	Teachers may wish to discuss the clotting process.
d. Lymph and lymph vessels	
1) Lymph	
Lymph is derived from the portion of the blood plasma that diffuses out of the capillaries. It surrounds the body cells as intercellular fluid and helps transport dissolved materials between the capillaries and the cells.	
2) Lymph vessels	
Excess intercellular fluid enters lymph vessels and is circulated through these vessels as lymph. Lymph vessels transport the lymph to veins where it enters the blood and becomes a portion of the plasma again.	Use a diagram or chart of the lymph system to discuss its function in the circulation of materials. Discuss functions of lymph nodes.
	Use a diagram of blood and lymph capillaries passing through a body tissue. Discuss the exchange of materials and their direction of movement into or out of the blood.
	Lymph is circulated in lymph vessels by the contraction of body muscles.
2. Pathways of circulation	
Blood leaves heart ventricles and returns to an atria through a continuous pathway of blood vessels. There are two basic pathways:	Students should be able to label the major parts of a simplified diagram of the circulatory system showing pulmonary and systemic circulation.
a. Pulmonary circulation – involves blood flow from the right ventricle to the lungs where it receives oxygen and loses carbon dioxide and water vapor. The blood then returns to the heart by way of veins.	
b. Systemic circulation – involves blood flow from the left ventricle to all body parts and the return of the blood to the heart. This system provides the body cells with needed substances and carries away the cellular excretions.	

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
C. Transport System Disorders Some disorders of the transport system include: • High blood pressure • Leukemia • Coronary thrombosis • Anemia	Explain the symptoms and some of the possible treatments/causes of transport system disorders.
III. RESPIRATION Respiration involves the process of breathing and the chemical reactions of cellular respiration.	Review aerobic respiration from **Unit 1**.
A. Breathing Breathing includes the mechanisms involved in the inhalation and the exhalation of air.	
B. Cellular Respiration Cellular respiration is an energy-releasing process that takes place in living cells. Oxygen contained in inhaled air is used to break down sugar (glucose) and release energy. Molecules of carbon dioxide and water are waste products of this process.	Review concepts of cellular respiration which were discussed in **Unit 1**. Blow into limewater or bromthymol blue. Exhale on a cool glass surface. Discuss carbon dioxide and water vapor as products of respiration.
1. The respiratory (breathing) system The respiratory system, consists of nasal passages and tubes leading to and from the lungs.	A model or diagram can be used to demonstrate the positions of the respiratory organs.
a. Nasal passages The nasal passages are hollow cavities that extend from the nostrils to the throat (pharynx). The air is filtered, moistened, and warmed in the nasal passages before it enters the pharynx.	
b. Larynx The larynx (voice box) contains the vocal cords and is located at the upper end of the trachea. The epiglottis closes off the larynx and prevents food from entering it during swallowing.	Discuss how different sounds can be produced in the larynx.
c. Trachea The trachea (windpipe) transports air to the bronchial tubes. It is supported by rings of cartilage and is lined with cilia which transport foreign material out of it back to the nasal passages.	Discuss the function of the cartilage rings and the effects of damage to the cilia by smoking, pollution, etc.
d. Bronchial tubes The trachea joins the two bronchial tubes which branch into the lungs. Bronchial tubes are lined with cilia.	

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
e. Lungs Lungs are large, spongy organs within which the bronchial tubes branch into smaller tubes (bronchioles) eventually ending in air sacs known as alveoli.	A beef lung can be used to show the texture and relative size of lungs.
f. Alveoli An alveolus is a moist, thin-walled sac surrounded by a network of blood capillaries. As blood passes through the capillaries, oxygen in inhaled air is absorbed from the alveolus, and carbon dioxide and water vapor are released into the alveolus.	Construct a model of an alveolus using a balloon (alveolus) wrapped with twine (capillaries). The alveolus wall is thin and moist thus facilitating gas exchange. Discuss advantages of having an internal gas exchange system. Contrast this with the external gas exchange system of the earthworm.
g. Diaphragm and rib muscles The lungs have no muscle tissue to assist in inhalation or exhalation with the external environment. Air enters and leaves the lungs as a result of pressure changes in the chest cavity brought about by the contraction and relaxation of the diaphragm and rib muscles during inhalation and exhalation.	Use a bell-jar, rubber-balloon model of the breathing system to demonstrate the role of the diaphragm in regulating air pressure. If available, use a spirometer to measure respiratory volumes and capacities.
2. Control of breathing rate Many factors affect the breathing rate. Some of these include foreign particles from smoking and/or air pollution, and the oxygen, carbon monoxide, and carbon dioxide levels in the blood. The most important factor in controlling the breathing rate is the concentration of CO_2 in the blood. An increase in blood CO_2 concentration stimulates the brain stem which sends impulses to the diaphragm and increases the breathing rate. When the CO_2 level decreases, breathing rate decreases.	Compare breathing rate before and after exercise. Discuss the role of Cardiopulmonary Resuscitation (CPR).
C. Respiratory System Disorders Some disorders of the respiratory system include: • Bronchitis • Asthma • Emphysema • Lung cancer	Discuss effects of air pollution and smoking on the lungs. A cigarette smoked through a millipore filter can be used to demonstrate tar and other residues. Career: Respiratory Therapist Explain the symptoms and some of the possible causes/ treatments of respiratory system disorders.
IV. EXCRETION Waste materials formed as a result of cellular activities must be excreted in order to maintain life. An upset in the balance of body chemicals can lead to serious health	Ask students what would happen if wastes were not properly disposed of in a home, factory, or farm.

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
problems or death. The excretory system helps maintain a proper balance of body chemicals.	
A. Major Metabolic Wastes Some human excretions and the processes that produce them include: • Carbon dioxide – from aerobic respiration. • Water – from aerobic respiration and other cellular activities. • Urea – a nitrogenous waste from the breakdown of amino acids. • Mineral salts – from the breakdown of various compounds in the cell.	
B. The Role of Blood in Excretion Excretions leave body cells and enter the blood plasma, by the process of diffusion, through the intercellular fluid. The blood plasma transports these excretions to excretory organs which remove them from the body.	
C. The Excretory System Cellular wastes are excreted from four regions of the body.	
1. Skin The skin excretes nitrogenous waste, salts, and water (collectively known as perspiration) from the sweat glands through skin pores. The skin is also involved in controlling body temperature since the evaporation of perspiration causes cooling of the skin's surface.	Students should label a diagram of the skin. Evaporate alcohol from the skin to show the cooling effect of the evaporation of perspiration. Discuss the dangers of body painting by entertainers.
2. Lungs Lungs excrete carbon dioxide and water vapor by diffusion and exhalation.	Discuss exhalation of alcohol (detected by the Breathalyzer test) and the acetone breath of untreated diabetics.
3. Urinary system Some of the body's excretions leave by way of the urinary system which consists of the kidneys, ureters, urinary bladder, and urethra.	Use a diagram or chart to show the parts of the urinary system.
a. Kidneys Kidneys act as filters in the removal of urea, excess water, and salts from the blood. Vital substances that also diffuse out of the blood into the kidney are returned to the blood before the blood leaves the kidney.	Dissect a kidney of a mammal or use a kidney model. Dialysis and kidney transplants might be discussed here. Students are not required to know nephron structure and function. Careers: Lab technician Urologist

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
b. Ureters Each kidney funnels the excretions (collectively known as urine) into a tube known as the ureter.	
c. Urinary bladder Urine flows through ureters to the sac-like urinary bladder which stores this urine temporarily.	
d. Urethra The urinary bladder opens into a single tube (urethra) through which the urine leaves the body.	
4. Liver The liver, the largest internal organ in the body, produces urea (a nitrogenous waste) by breaking down excess amino acids. Other functions of the liver include the removal of poisons (including alcohol) from the blood and the storage of excess sugar as animal starch (glycogen).	Show liver size and location in a human torso model or chart/diagram. Fresh liver can be tested for the presence of animal starch.
D. Excretory System Disorders Some disorders of the excretory system include: • Kidney stones • Skin problems (blackheads, acne) • Cirrhosis of the liver	Explain the symptoms and some of the possible causes and treatments of excretory system disorders.
V. REGULATION Control and regulation of the body is brought about by the structures and actions of the nervous and endocrine systems. These two systems allow the human to adjust to internal as well as external environmental changes.	
A. Nerve Regulation A stimulus is a specific change in the environment which affects the nervous system. A response is a reaction to this stimulus. Many organs and glands of the body receive stimuli which are translated into impulses. The impulses are then transferred by nerve cells to the central nervous system which sorts out the incoming impulses, interprets their meaning and transmits the impulses to organs or glands. These organs and glands provide specific responses to these impulses.	Make a sudden loud sound and discuss the response of the students.

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
1. The nervous system	
Major components of the nervous system include:	Use audiovisual media about the anatomy and functions of the nervous system. The nervous system is divided into two major parts: • Central nervous system; brain and spinal cord. • Peripheral nervous system; the nerves that lie outside the central nervous system.
a. Nerve cell (Neuron)	
The basic unit of the nervous system is the nerve cell. The nerve cell is specialized to receive impulses and send them to various body parts. Nerve cells make up the structure of the nerves, brain, spinal cord, and receptors.	Use a diagram or chart and discuss the parts of a nerve cell. Point out synapses between nerve cells and discuss how impulses cross a synapse with the help of a neurotransmitter. Teachers may wish to discuss the structure and function of a ganglion or plexus.
b. Nerve	Compare a nerve to a telephone cable line.
A nerve is a bundle of nerve cell processes held together by a tough protective membrane.	Nerves are classified according to function. • Sensory nerves – transmit impulses to the central nervous system • Motor nerves – transmit impulses from the central nervous system to various body parts. Most nerves contain both sensory and motor fibers (mixed nerves).
c. Brain	
The brain is the major control center of the body. It consists of three major regions: • Cerebrum – center of thinking, memory, emotions, sensory impulse interpretation, and voluntary activity. • Cerebellum – coordination of muscles and the center of balance. • Brain Stem (Medulla) – center of respiration, heartbeat, and other involuntary activities.	Students should be able to label major brain divisions on a brain diagram. Use a freshly dissected or preserved brain or a model to demonstrate brain parts. Point out brain convolutions and relate them to increased surface area. Discuss the effects of drugs on the brain (e. g. , alcohol, LSD).
d. Spinal cord	
The spinal cord is the tubular mass of nerve cells that extends from the brain stem down through the center of the spinal column. The spinal cord relays impulses to and from the brain and is the center of some reflex actions.	Discuss the results of traumatic injury to the spinal cord (i. e,. paralysis, death).
e. Receptors	
Receptors are special structures which are sensitive to stimuli. External receptors include the eyes, ears, nose, tongue, and skin. Stimuli for these receptors are light, sound, chemicals, and temperature/pressure changes.	It is not necessary to discuss the structure of the various receptor organs.

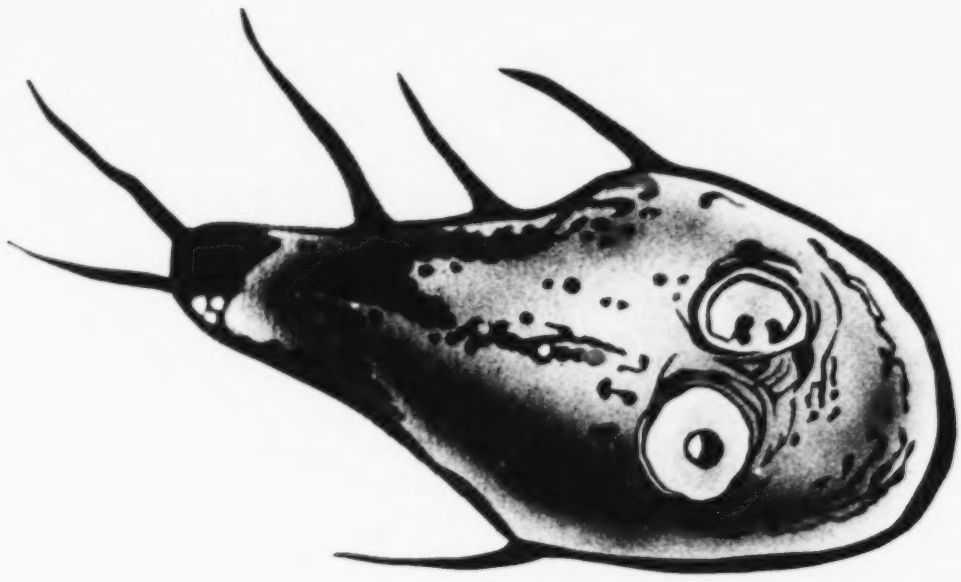
UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
Internal receptors located in the internal organs allow the brain to detect hunger, thirst, muscle position, and carbon dioxide levels in the blood.	
2. Types of behavior The total response of an organism to stimuli is known as behavior.	
a. Involuntary nerve pathways Involuntary actions occur automatically without conscious control. Some involuntary actions are inborn while others are learned.	Examples of involuntary actions which are inborn include: contraction of heart and diaphragm muscles, secretion of glands, and simple reflexes such as the knee jerk and iris movement. Examples of involuntary actions which are acquired by the individual through repetition include: writing one's name, riding a bike, and playing a musical instrument. Demonstrate the knee jerk reflex as an example of an involuntary action. Iris dilation in reduced light and contraction in bright light may also be demonstrated. Illustrate a simple reflex with a diagram of the reflex arc. Indicate sensory and motor neurons, synapses, receptor, effector and interneuron. Students should be able to label a diagram of a reflex arc. *What is the time required for a reflex response?* • Investigate student responses with appropriate reaction time activities.
b. Voluntary nerve pathways Voluntary actions require thinking. The impulses originate in the brain and are carried by nerve cells to muscles or glands which respond in the appropriate manner.	Voluntary actions include measuring with a meter stick, picking up a book, and building a model airplane.
3. Nervous system disorders Some disorders of the nervous system include: • Cerebral palsy • Meningitis • Polio	Explain the symptoms and some of the possible causes/treatments of nervous system disorders.
B. Chemical Regulation Stimuli may cause certain glands to secrete chemical messengers known as hormones. These hormones cause other parts of the body to respond.	
1. The endocrine system The endocrine system is composed of ductless glands which produce hormones.	

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
Endocrine glands include the pituitary, thyroid, pancreas, adrenals, and gonads.	Use a diagram/chart to locate and name some of the endocrine glands. Examples of hormones and their functions can be included at this time but are not necessary.
Hormones secreted by these ductless glands diffuse from the glands directly into the blood plasma. The blood transports the hormones to various body areas which respond to them.	Present audiovisual media on the endocrine glands and their functions.
2. Examples of hormonal action	
The proper amount of sugar (glucose) in the blood plasma is regulated by hormones: • Insulin – secreted by the pancreas; lowers the blood sugar level. • Glucagon – secreted by the pancreas; raises the blood sugar level. • Epinephrine (adrenalin) – secreted by the adrenal glands; raises the blood sugar level.	If the proper blood sugar level is not maintained, conditions such as diabetes, coma, fainting, hyperglycemia, hypoglycemia and even death may result. Functions of sex hormones are described in **Unit 4**.
3. Endocrine system disorders	
Endocrine system disorders include: • Goiter • Diabetes	Show photos, slides, or a film of some endocrine disorders. Explain the symptoms and some of the possible causes and treatments of endocrine disorders.
VI. MOVEMENT AND STRUCTURAL SUPPORT (MUSCLES AND SKELETON)	
The interaction of muscles with the skeleton brings about body movements (locomotion).	
A. Advantages of Locomotion	
Locomotion increases the chances for survival of an organism by enabling the organism to gather food, seek shelter, and escape dangerous situations. Locomotion also increases the chances for survival of a species by enabling members of the species to find suitable mates.	
B. Structures Involved in Locomotion	
Human locomotion involves the interaction of joints and tissues such as bone, cartilage, muscles, tendons, and ligaments.	*What structures are involved in locomotion?* • Dissect an uncooked chicken wing. Locate joints, muscles, nerves, bones, tendons, cartilage, and ligaments. List functions of these structures.
1. Bones, cartilage, and joints	
The bones of the skeleton support and protect body organs. They also provide a place for muscle attachment. In addition, blood cells are produced in the marrow of some bones.	Use a skeleton, chart, or diagram to show the skeletal framework. Teachers may wish to identify some of the larger bones by name.

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
The bones of the skeleton contain living cells – blood, fat, and bone cells. The hardness of the bone is provided by calcium and phosphorus minerals.	*How is bone constructed?* • Examine a fresh bone cross section. Note the membrane on the bone exterior, blood vessels, and the marrow.
Certain areas of the skeleton such as the nose, ribs, and spinal column include flexible cartilage. Bones are connected at places called joints. The ends of bones at the joints also contain cartilage.	Soak a bone overnight in diluted nitric acid to remove its minerals. Demonstrate the "rubber" bone to the students the next day.
Most joints allow for bone movement. Ball and socket joints are located at the hip and shoulder. They permit circular movement. Hinge joints located at the elbow and knee allow for movement in one plane only. Hinge joints do not permit the universal movement that ball and socket joints provide. Fluids in the joint help cushion and lubricate the joint.	Obtain an articulated joint from a butcher and demonstrate the nature of its movement. Point out joints in a skeleton – ball and socket, hinge, pivot, and gliding. Fused joints are located in the skull.
2. Muscles	
Muscles produce body movement by pulling on bones when they contract. Muscles also produce body heat when they contract.	Measure the lifting power of muscles in the body. Determine the relative strength of finger, arm, and leg muscles by lifting increasingly heavy objects. Graph results.
3. Tendons and ligaments	
Tendons are bands of dense tissue that connect muscles to bones. Ligaments are tough bands of tissue that hold bones together at joints.	Have students locate the Achilles tendon attached to the heel.
C. Muscle Action	
Nerves direct impulses to muscles causing them to contract. The energy needed for the muscle to contract comes from energy stored in chemicals such as glycogen.	
Muscle cells will continue to operate even if they do not receive sufficient oxygen. Under these (anaerobic) conditions they produce lactic acid which causes muscle fatigue. Rest after exercise supplies oxygen to fatigued muscle cells. During this rest-recovery period, the lactic acid is removed and energy-storing compounds are built up again.	Have a student squeeze a rubber ball and hold it. Discuss the resulting muscle fatigue. Review concepts of aerobic and anaerobic respiration covered in **Unit 1**.
D. Muscle Function (Involuntary/Voluntary)	
Voluntary muscles attach to the skeleton and can be controlled for locomotion. Certain involuntary muscles are responsible for other body movements (involuntary activities) such as heart contractions and peristalsis.	Show photos, diagrams, charts, films, or filmstrips of the three types of muscle tissue; skeletal (striated), cardiac, and smooth. Discuss which are voluntary or involuntary.

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
E. Muscle-Bone Disorders Some disorders of the muscle-skeletal system include: • Fractures • Hernias • Sprains	Show x-rays of fractures and dislocations. Explain the symptoms and some of the possible causes and treatments of muscle and bone disorders. Careers: Athlete Coach/Trainer Physical Therapist

UNIT 3
VARIETY AMONG LIVING THINGS



INTRODUCTION

This unit includes a survey of some of the differences among different forms of life, comparing their basic structure and how they function. The biological impact that different organisms have on humans and other living things is considered along with some economic uses of various organisms for the benefit of human life.

OBJECTIVES

Upon completion of the study of this unit, the student should be able to:

- Recognize and differentiate among some of the varieties of life forms.
- Identify some structural and functional similarities and differences among diverse forms of life such as viruses, bacteria, fungi, algae, protozoa, plants, and animals.
- Recognize how the activities of some organisms affect the quality of human life or the activities of other organisms.
- Identify some economic uses of a variety of life forms.

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
I. SOME SIMPLE ORGANISMS	
Living things are complex. However, certain characteristics (structural and/or functional) make some organisms simpler in form than others.	Some teachers may wishto begin this unit with the principles of classification from **Unit 6.**
	Some scientific names are used in this unit. Explain that these Latin names are widely used and consist of two parts (like a last name followed by a first name). Other details of classification such as the categories of genus and species and the classification system will be covered in **Unit 6.**
A. Viruses	
1. Characteristics	
a. Structural	
There is disagreement as to whether viruses should be called organisms or even whether a virus can be considered to be "alive."	
A virus is not a cell. It consists of hereditary material enclosed in a coat of protein. Viruses are smaller than most cellular organisms.	Discuss the need for the electron microscope in virus study.
b. Functional	
Viruses do not carry on most metabolic activities.	
Viruses can only make copies of themselves inside a living cell. Outside a living cell, a virus is "lifeless" (often existing in crystalline form) with no means of locomotion.	Careers: Lab Technician Disease Control Specialist
2. Role	
Viruses cause infections in both plants and animals. Some viruses cause tumors and warts. Viruses destroy cells and are responsible for diseases in humans such as polio, measles, mumps, influenza, hepatitis, colds, and AIDS.	Show photographs and diagrams of various virus types. Recent research has linked certain cancers to the activity of some viruses.
3. Economic uses	
Some viruses are used in the control of insect pests. Viruses are used in genetic research.	Viruses have been used in the biological control of caterpillars of the European pine sawfly and the gypsy moth.
B. Bacteria	
1. Characteristics	
a. Structural	
Bacteria are microscopic, unicellular (one-celled) organisms which lack a nuclear membrane.	*How can bacteria be studied in the laboratory?* • Grow bacteria from various sources in petri dishes of agar and observe the characteristics of bacterial colonies. Tape down the petri dish cover after exposure and dispose of properly. • Observe prepared microscope slides of mixed bacteria. Identify the three basic forms of bacteria: round, rod, and spiral shaped.

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
b. Functional	
Bacteria, living as parasites, absorb food materials from other living organisms (their hosts) or, living as saprophytes, digest and absorb food materials from dead organisms. They are found in or on practically everything, living and nonliving. Most bacteria are free-living and beneficial to humans.	Careers: Bacteriologist Lab Technician
Conditions that favor bacterial growth are: warmth, moisture, suitable food, and darkness.	Reproduction and the reproductive structures are treated in **Unit 4**.
2. Role	
a. Decomposer	
Bacteria are decomposers that cause decay. Decay is necessary for natural recycling processes. During decay, complex substances are broken down into simple compounds which can be used again by other organisms.	
b. Food spoiler	
Bacteria spoil food by secreting enzymes into the food causing it to decompose. In addition to enzymes, other substances produced by bacteria are released into the food. Some of these substances are toxic, making the food poisonous to humans and other organisms.	*How can food spoilage by bacteria be prevented?* • Put petri dishes of bacteria in the refrigerator. Compare to dishes of bacteria at room temperature. • Discuss methods of killing bacteria in foods: pasteurization, canning, chemical preservatives, radiation, steam/pressure, salt curing, and dehydration. Discuss botulism and the anaerobic conditions that favor its growth in canned foods.
c. Polluter	
Bacteria in great numbers can pollute lakes, streams, and drinking water. Substances produced by bacteria in these water supplies can cause the death of other organisms. The respiratory activities of bacteria can reduce the dissolved oxygen content in these water supplies.	
d. Pathogen	
Many bacteria are pathogenic. A pathogen is an organism that causes disease and/or infection.	Some bacterial diseases of humans are tuberculosis, tetanus, and strep throat. *How can we control the spread of pathogenic bacteria?* • Demonstrate the effects of antibiotic discs and/or discs soaked in varous mouthwashes, on the rate of bacteria growth. Discuss the use of antiseptics and disinfectants in the control of bacteria. Teachers may wish to discuss the incidence of recent antibiotic resistance in bacteria.

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
3. Economic Uses	
Bacteria are used in sewage disposal plants and home septic systems to break down solid wastes to simpler substances that can be disposed of more easily.	Take a field trip to a local sewage disposal plant or have a local sanitation engineer as a speaker.
By using methods of gene transplanting, bacteria have been induced to produce substances such as insulin which are valuable to humans.	
Many foods, such as sauerkraut, yogurt, vinegar, and cheese, are flavored or produced as a result of bacterial activities.	Demonstrate how sauerkraut or yogurt is made.
Bacteria are used in the tanning of leather, the curing of tobacco, and the production of silage for feeding cows.	
C. Fungi	
1. Characteristics	
a. Structural	
Fungi lack roots, stems, and leaves and exist in a variety of forms. Some types of fungi include yeasts, mushrooms, molds, puffballs, and mildews.	*How can fungi be studied in the laboratory?* • Observe yeast, breadmold, and fresh mushrooms. Identify structures using dissecting microscopes, hand lenses, or compound microscopes. • Observe puffball or breadmold spores. • Examine a rotting log and/or moldy food.
b. Functional	
Fungi lack chlorophyll and are unable to produce their own food. Like bacteria, most fungi live as saprophytes or parasites.	Review the definition of saprophyte and parasite.
2. Role	
a. Decomposer	
Like bacteria, some fungi are decomposers causing the decay of dead plant and animal tissues. These decay products help to maintain soil fertility.	Show samples of humus and compare to sand or soil containing little organic material. Point out the water-holding capacity of soil which is rich in organic matter. (See **Unit 7** for additional information on decomposers.)
b. Food spoiler	
Some fungi such as molds and yeasts grow in and on foods making them unsuitable to eat.	Bring in samples of food that show destruction by fungi (e. g. , moldy bread, moldy fruit).

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
c. Pathogen	
Some fungi cause human skin disorders such as athlete's foot and ringworm. Other fungi cause destructive plant diseases, such as corn smut.	Show photos of athlete's foot and ringworm growing on human skin. Use visual aids to illustrate corn smut and wheat rust. Pathogenic fungi are generally host specific.
3. Economic uses	
Many fungi are used directly for food (mushrooms) or are used in food industries, such as cheesemaking. Carbon dioxide and ethyl alcohol released as waste products by yeast are used in the baking and alcoholic beverage industries.	*How can you observe fermentation activity of yeast?* • Set up a fermentation apparatus to show fermentation of grape juice by yeast. Test the gas given off with limewater or bromthymol blue.
Many fungi are used to produce antibiotics.	Penicillin is produced from the *Penicillium* mold and streptomycin from the soil fungus, *Streptomyces*.
D. Algae	
1. Characteristics	
a. Structural	
Algae exist as single cells, sheets of cells, balls of cells, or as chain-like filaments. Algae vary in size from microscopic to more than 50 meters in length.	*How can you study algae in the laboratory?* • Observe fresh specimens or prepared microscope slides of Spirogyra and Protococcus with the microscope. Locate the chloroplasts. Note the lack of roots, stems, or leaves.
b. Functional	
Most algae carry on photosynthesis and are nutritionally independent.	Review the photosynthesis process introduced in **Unit 1**.
2. Role	
a. Producer	
Algae are the principal food producers in aquatic environments. They are the basic source of food and oxygen for most aquatic organisms.	Discuss the role of algae in providing a major portion of our world's food supply. Teachers may wish to use the term "autotrophic."
b. Polluter	
Large numbers of certain types of algae in water supplies often render the water unfit for human uses.	Use visual aids to show the causes and effects of water pollution.
3. Economic uses	
Algae and/or their products have been used as soil fertilizers (seaweeds), in foods (soups, flour, ice cream), and as a source of agar (a medium used in laboratories for growing bacteria).	Careers: Marine Farming Environmental Engineer Water Treatment Specialist

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
E. Protozoa	
1. Characteristics	
a. Structural	
Protozoa are microscopic, unicellular organisms having specialized cell organelles. They exist in many different forms and are classified into groups depending on their means of locomotion.	*How can you study the structures and functions of protozoa?* • Observe the many diverse forms of protozoa found in pond water with the compound microscope. • Observe live amoebas and paramecia with the compound microscope. Identify cell organelles and their associated functions. • Observe paramecia feeding on stained yeast cells.
b. Functional	
Special cell organelles such as those found in the amoeba or the paramecium have special functions to perform.	Show filmloops of protozoans to demonstrate organelles and their associated functions.
2. Role	
a. Food for other organisms	
Protozoans feed on small organisms and in turn are fed on by larger organisms. They thus occupy an important link in aquatic food chains. Some protozoa help digest food in the digestive tracts of animals such as cattle and termites.	Discuss ingestion, digestion, respiration, excretion, and locomotion in the amoeba and paramecium. Discuss the role of symbiotic protozoans in the termite.
b. Pathogen	
Human diseases such as malaria, African sleeping sickness and amoebic dysentery are caused by protozoans.	Choose one of the pathogenic protozoans and briefly trace its life cycle. Discuss the terms vector and host. Careers: Medicine (Pathologist) Protozoologist
3. Economic uses	
The shells of certain protozoans produce limestone and chalk.	
II. COMPLEX ORGANISMS	
Plants and animals are more complex in form than the simple organisms treated in I.	

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
A. Plants	
1. General characteristics	
Plants have cell walls and chloroplasts. They are many-celled (multicellular) and make their own food by photosynthesis. Most plants have roots, stems, and leaves. Some environmental needs of plants are: light, oxygen, water, carbon dioxide, and minerals such as nitrates.	Some cells of plants may lack chloroplasts (e. g. , root cells). A few true plants such as dodder and Indian pipe do not photosynthesize.
2. The role of plants as producers	
Plants, along with algae, are the major producers in nature. Their photosynthetic activities provide food for organisms such as animals, nongreen plants, fungi, and bacteria which cannot make their own food.	The role of the plant as producer is treated in detail in **Unit 7**.
3. Major plant divisions	
Plants exist in a variety of forms. They may be classified as nonvascular or vascular.	*How can you distinguish between vascular and nonvascular plants?*
a. Nonvascular plants	• Observe preserved or living examples of mosses, liverworts, ferns, conifers, and flowering plants to demonstrate plant diversity.
Nonvascular plants do not have specialized tissues for conduction and support (vascular tissue). Examples of nonvascular plants include mosses and liverworts.	
b. Vascular plants	
Vascular plants have specialized tissues for conduction and support (vascular tissue). Vascular tissue consists of xylem tubes which conduct water and minerals and phloem tubes which transport soluble foods. Vascular tissue is located in leaves, stems, roots, and flowers. Examples of vascular plants include: ferns, trees, grasses, and roses.	Many vascular plants are of particular interest due to their unusual characteristics, e. g., venus fly trap, pitcher plant, sensitive plant, jewel weed and aloe. Discuss one or two of these.
1) The leaf	
The leaf is the primary site of photosynthesis. The specialized structure of the leaf makes it well adapted for the process of photosynthesis. Some of these adaptations include: • Large, flat surface for maximum light absorption • Stomates and air spaces for gas exchange • Many chloroplasts in the palisade and spongy layers. • Arrangements of leaves on stems for maximum light reception. • Guard cells in the epidermis for stomate size regulation. • Veins containing xylem and phloem cells for conduction.	Students should be able to identify (and associate functions with) leaf structures such as: wax cuticle, epidermis, palisade and spongy cells, veins with xylem and phloem, air spaces, stomates, and guard cells. *How can you study leaf structure and function?* • Observe prepared microscope slides of leaf cross sections and leaf epidermis. • Test a *Coleus* leaf for starch with iodine. Note how starch storage areas coincide with leaf areas that contain chlorophyll. • Test the gas given off by Elodea when it is placed in a test tube of H_20 and placed in sunlight.

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
In addition to photosynthesis, other functions of leaves include:	• Use living plants and observe leaf surface area, leaf arrangement on the stem, simple and compound leaves and different venation patterns. Note variations in leaf thickness and amount of waxy cuticle. Compare with a cactus. • Place a plastic bag over a potted plant and note the condensation.
• Production and storage of nutrients such as proteins, fats, oils, vitamins, and starch.	Use plastic pop-beads to show how glucose is bonded together and forms large molecules such as in a starch.
• Aerobic respiration.	Review photosynthesis and aerobic respiration reactions. Use a diagram of a leaf cross section to show the site of these reactions. Note how the raw materials needed for these reactions reach the leaf cells and how waste products exit.
• Transpiration – the loss of water vapor through the stomates into the atmosphere.	Discuss the role of transpiration in helping water and minerals move up xylem tissue which is continuous from root to stem to leaf. Discuss the mechanism of leaf coloration changes in the fall season.
2) The stem The stem is the major transport structure between the leaves and the root. It stores food and is involved with the production and display of leaves and reproductive structures such as flowers and cones. Young green stems carry on photosynthesis.	*How can you study stem structure and functions?* • Place the stem of a white carnation or celery, in a beaker of food coloring. Note the absorption and transport of color and relate this to xylem tissue and transpiration.
Vascular plants whose stems increase in width each year are known as woody plants.	• Observe a prepared slide of a woody stem cross section and identify the bark, cambium, xylem, and phloem. • Examine a large cross section of a tree trunk and locate the bark, cambium, and xylem. Locate the heartwood and sapwood. • Observe a woody twig such as horse chestnut and identify the major external features. Associate stem functions with these structures. Discuss the effect of bark beetles on elms and other trees. Beetles may be a vector of disease such as Dutch elm fungus.
Some important external woody stem structures include the terminal bud, bud scale scars, lenticels, and leaf scars.	Discuss how the position of bud scale scars is used to provide information on the growing season and on the age of the stem. Discuss what causes the leaf to drop from the stem in the fall season.

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
Some adaptations of stems which enable them to perform their functions include: • Vascular tissue (xylem and phloem) for transport. • Lenticels for gas exchange. • Chloroplasts in young stems for photosynthesis. • Buds for production of new tissues. • Special growth areas (cambium and stem tip).	Discuss tree girdling and the value of wrapping the base of fruit trees with burlap or tar paper.
3) The Root The root is adapted for anchorage, absorption of water and minerals, storage of foods, and transport activities. Roots have living, growing parts which require a supply of oxygen for aerobic respiration.	Although plant growth is summarized in **Unit 5**, it may be included in this unit. *How can you study root structure and function?* • Observe a prepared slide of a root cross section and identify root structures such as: epidermis, root hairs, storage tissue, vascular tissue, cambium, and rootcap. Associate functions with the various root structures. • Observe and identify regions in fresh carrot cross sections. • Germinate radish seeds in petri dishes containing moist filter paper. Observe the development of root hairs.
Some adaptations of roots which enable them to perform their functions include: • Root hairs for absorption. • Vascular tissue for transport. • Special areas for food storage. • Special growth areas (cambium and root tip).	Use class discussion and visual aids to explain and demonstrate: • Types of root systems – taproot, fibrous. Indicate the soil-holding capacity of fibrous roots in erosion areas. • Wilting – Use potted plants to demonstrate the process. Discuss the wilting that results from transplanting. • The purpose of holes in the bottom of flowerpots and the effect of prolonged flooding on trees. • The purpose of cultivating the soil before planting seeds. Include the role of the earthworm.
4. Economic uses of plants (plant products) Some plant parts used directly for food are: • Roots – carrot, beet, radish, turnip. • Stems – white potato, asparagus. • Leaves – lettuce, spinach, cabbage. • Fruits – apples, tomatoes. • Flowers – cauliflower, broccoli • Seeds – nuts, beans	Name some specific types of drugs, oils, flavorings, and fibers that come from plants. Some plants or plant parts are poisonous, e. g. , poison ivy, deadly nightshade, poinsettia, mistletoe, and rhubarb leaves.

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
Plants are the source of many products used by humans, such as: rope, turpentine, fats, oils, drugs, dyes, fibers for clothing, flavorings, sugar, lumber, paper, and flour.	Careers: Horticulture Forestry
B. Animals	
1. General characteristics	
Animals are multicellular, with cells lacking cell walls and chloroplasts. Most animals possess the ability to carry on locomotion (move from place to place). Animals are unable to produce their own food.	
2. The role of animals as consumers	
Animals occupy the role of consumers in nature because of their inability to carry on a foodmaking process such as photosynthesis. Animals are eaten by other animals for food and their waste products (carbon dioxide, water, nitrogenous and solid wastes) contribute to the Earth's recycling processes.	The role of the animal as a consumer is treated in greater detail in **Unit 7**.
3. Major animal divisions	
Animals exist in a variety of forms. They may be classified as invertebrates or vertebrates.	*How can you distinguish between vertebrate and invertebrate animals?* • Examine living and/or preserved examples of invertebrates and vertebrates. Identify them and note some similarities and differences between them.
a. Invertebrates	*How can you study invertebrate structure and function?*
An invertebrate is an animal without a backbone. Invertebrates have specialized organs which perform the necessary life functions of nutrition, transport, respiration, excretion, regulation, and locomotion. Invertebrates include sponges, jellyfish, starfish, worms, clams, and insects.	• Dissect an invertebrate such as a grasshopper, crayfish, earthworm, or starfish and identify organs with their functions. Before the dissection, study diagrams, films, filmstrips, and descriptions of the organism to be dissected.
b. Vertebrates	
A vertebrate is an animal with a backbone. Vertebrates have specialized organs which perform the necessary life functions. Vertebrates include fish, amphibians, birds, reptiles, and mammals.	Details of vertebrate structures and functions are included in the study of the human in **Unit 2**. A vertebrate dissection is included in **Unit 2**.
4. Economic uses of animals (animal products)	
Animals and animal parts are used directly for food, such as: seafood (clams), muscle tissue (steak), and organs (liver). Animals are the source of many products used by humans, such as: leather, furs, antibodies, hormones, fertilizers, perfume, silk, hair, fats, and oils.	Name some specific types of antibodies, hair, oils, and hormones that come from animals. Discuss some specific examples of animal products, such as: insulin, cod liver oil, and cowhide.

UNIT 4
CONTINUATION OF LIFE: REPRODUCTION AND DEVELOPMENT

INTRODUCTION

This unit deals with the reproductive processes necessary to maintain the existence of a species. Topics include sexual and asexual patterns of reproduction in animals and flowering plants. Emphasis is placed on human sexual reproduction.

OBJECTIVES

Upon completion of this unit, the student should be able to:

- Define reproduction and relate the process of reproduction and development to species survival.
- Differentiate between sexual and asexual patterns of reproduction.
- Identify the major structures and processes involved in animal and plant sexual reproduction.
- Identify the major types of asexual reproduction in animals, plants, and simple organisms.

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
I. REPRODUCTION AS A LIFE FUNCTION	
Reproduction is a life function in which living things produce new living things of the same species.	
A. Reproduction and Cell Division	
Individual cells reproduce by means of cell division. This process involves a complex series of changes in the nucleus of a cell leading to the production of two new cells whose nuclei are identical to each other and to that of the parent cell.	Briefly review major life functions covered in **Unit 2**. This reference to cell division is essentially a review of the concept as introduced in **Unit 1**.
Cell division in unicellular organisms is a form of reproduction known as fission.	Teachers may wish to introduce the details of mitosis at this time. See **Unit 5** for appropriate understandings.
B. Reproduction and Species Survival	
Periodically, unicellular organisms must divide for the survival of the species. Likewise, members of a multicelled species must reproduce periodically in order for the species to survive from generation to generation. If reproduction were neglected by a species for even one generation, the species would become extinct.	Cell survival is partially dependent on the maintenance of a proper surface area to volume ratio. Cell division helps to maintain this ratio.
C. Types of Reproduction	
Two major types of reproduction common to living things are sexual and asexual.	
II. SEXUAL REPRODUCTION	
Sexual reproduction is a type of reproduction which involves the union of two nuclei from special sex cells which are usually produced by two separate parents. It is the type of reproduction used by most animal and plant species.	
A. Sexual Reproduction in Animals	Animal reproduction as presented here is essentially mammalian (human) reproduction.
1. Sex cells	
Sexual reproduction involves specialized cells known as sex cells, or gametes.	
These sex cells are fragile and short-lived. They are formed as a result of the type of cell (nuclear) division known as meiosis.	Teachers may wish to introduce the details of meiosis at this time. See **Unit 5** for appropriate understandings.
	Career: Animal breeder
Males of animal species produce gametes known as sperm cells, which are very small, mobile cells. Females of animal species produce gametes known as egg cells, which are normally larger than the sperm cell, and contain a supply of food (yolk) to nourish the developing embryo. The number of sperm produced greatly exceeds the number of eggs produced by a species.	*What adaptations promote reproductive efficiency?* • Observe eggs of frogs or fish, if available, to investigate structure. • Observe unfertilized chicken eggs to identify reproductive adaptations.

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
Both the sperm cell and egg cell contain genetic information responsible for the characteristics and development of the new, living organism.	Genetic inheritance via gametes in treated in more detail in **Unit 5**.
2. Specialized reproductive systems	
Most animals, including humans, contain specialized structures to aid the process of reproduction.	
Female system – Major parts include: • Ovaries (produce eggs; sex hormones) • Oviducts (transport eggs) • Uterus (serves as the site of embryonic development) • Vagina (receives sperm, acts as the birth canal).	Teachers may wish to discuss the structure and function of the cervix. Use a diagram to illustrate parts of the female reproductive system.
Male system – Major parts include: • Testes (produce sperm; sex hormones) • Sperm ducts (transport sperm) • Penis (implants sperm) • Glands (activate and protect sperm)	Use a diagram of the male reproductive system to show the anatomical relationship of the vas deferens, urinary bladder, and urethra. Glands include prostate and seminal vesicle.
3. Reproductive system function	
a. Female sexual cycle	
The female sexual cycle (menstrual cycle) involves the preparation of the body to support the growth of an embryo/fetus. Eggs developing in the ovaries are released periodically (on a monthly basis) into the oviduct by a process known as ovulation. The uterine lining thickens during this part of the menstrual cycle to receive the developing embryo. The eggs disintegrate if they do not encounter sperm cells. If an embryo does not develop, the uterine lining is shed and passed out of the body in the process known as menstruation.	Hormonal control of the menstrual cycle may be mentioned. Details of menstrual cycle are not required. Use a filmstrip or other media to illustrate the human female sexual cycle.
b. Male sexual function	
Beginning at the time of puberty, the male sexual function involves the constant production of sperm in the testes. Semen (sperm mixed with fluids from glands) is conducted to the body exterior through the sperm ducts and urethra. The process by which sperm passes out of the body is known as ejaculation.	
c. Sexual intercourse	
During sexual intercourse (copulation) the penis becomes modified (erect) for the efficient transfer of sperm into the vagina.	Family planning may be mentioned here at district option. Teachers may wish to relate family planning to human population growth (**Unit 7**).
d. Fertilization	
After sexual intercourse, the sperm cells swim through the female reproductive tract and enter the oviducts. If they encounter an egg in the oviduct, the egg and a	

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
sperm cell may fuse. The fusion of a sperm cell nucleus and an egg cell nucleus is known as fertilization. A fertilized egg is known as a zygote.	
e. Early develop_nent	
During development, the zygote undergoes rapid cell division (cleavage) and becomes an embryo. The embryo normally implants itself in the lining of the uterus, which has thickened during the menstrual cycle. The embryo continues development there and becomes a fetus. To support this development, nutrients pass from the mother's blood to the embryo's blood within an organ known as the placenta.	Teachers may wish to contrast placental development with other types of development (marsupial, bird, etc.).
	Emphasize that no direct connection exists between embryonic and maternal blood streams. Fetal blood may, however, enter the mother's blood at birth.
	Show cleavage models leading to embryo formation. It is not necessary to name the stages.
	How can you study early embryonic stages? • Observe slides of starfish cleavage and note the series of cell divisions that lead to the formation of an embryo. • Contrast early human development with that of a chicken or a fish.
The placenta is composed of tissue derived from the mother and the embryo. The umbilical cord, which connects the embryo to the placenta, transports materials between the embryo/fetus and the placenta (oxygen, wastes, nutrients). During development, the embryo is surrounded by amniotic fluid which is enclosed by a protective membrane known as the amnion.	Discuss amniocentesis.
f. Gestation and prenatal care	
The period of development (gestation) in humans is approximately nine months. During this time, it is essential that the expectant mother provide good prenatal care by eating nutritious foods, avoiding alcohol, tobacco, and drugs, and receiving proper medical attention regularly.	Emphasize that good prenatal care will help assure a healthy baby. Relate use of tobacco, alcohol, and drugs to incidence of "low birth weight" syndrome, as well as to the incidence of birth defects.
g. Birth and postnatal care	
Birth occurs when the fetus has matured and begins to move down the birth canal. This movement is aided by strong muscular contractions of the uterus. Following birth, the placenta is discarded from the mother's body and the mother begins producing milk from mammary glands located in the breasts. This milk is normally the best natural food for a newborn baby. The baby should receive regular medical attention and other postnatal care as it grows.	Discuss the origin of the "belly button."

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
4. Animal growth	
Animal growth and development is accomplished by the continued division of cells and usually results in an organism reaching a predetermined size (adult). During this period, cells and tissues mature and become specialized.	Although there is usually no appreciable growth after an organism becomes an adult, cell division and specialization continue until death.
5. Human reproductive disorders	
In some geographic areas, sexually transmitted diseases have reached epidemic proportions in recent years. They may be transmitted by both males and females and may cause sterility or death if not treated by a competent physician. Early treatment usually leads to recovery. Sexually transmitted diseases of humans include: • Syphilis • Gonorrhea • Genital Herpes	Emphasize dangers of self-diagnosis and self-treatment of sexually-transmitted diseases. Other disorders associated with the human reproductive tract include: prostate enlargement, cancer. Prostate enlargement is most common in males over 40 years of age. Breast cancer is a major cause of death of women who are 25-45 years of age.
B. Sexual Reproduction in Flowering Plants	
1. Sex cells	
Sperm nuclei produced by most flowering plants are contained in pollen grains. Egg nuclei are contained in ovules. Both kinds of nuclei contain genetic information important in determining the characteristics of offspring.	
2. Flower structure	
In a flowering plant, structures known as stamens are the sites of pollen grain formation. Structures known as pistils are the sites of ovule formation. Accessory flower parts include: • Petals • Sepals	
3. Flower function	
Pollination occurs when mature pollen grains are transferred from the anthers of stamens to the stigma of the pistil. Cross-pollination occurs between separate plants. Self-pollination occurs within the same plant/flower. During the germination of the pollen grains, the pollen forms a tube which grows down the pistil to the ovule(s) in the ovary at the base of the pistil. Sperm nuclei travel down the pollen tube and fuse with egg nuclei inside the ovules (fertilization).	A typical, complete flower is assumed here. *What adaptations promote reproductive efficiency in plants?* • Dissect flowers and relate the function of the flower parts to their location. • Observe different kinds of fruits. Dissect fruits to locate seeds and other parts. • Dissect a bean seed. Locate the embryo and areas of stored food.

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
During a period of development, the fertilized ovule develops into a seed, which becomes enclosed by a fruit. The fruit aids in seed dispersal, thereby promoting species survival.	
4. Seed Dispersal	
Seeds must be spread away from the parent plant in order to minimize competition with the parent for favorable growing conditions.	Agents of seed dispersal include wind, water, mechanical, fire, animals.
5. Seed germination	
The seed contains a food supply and an embryo plant which begins to grow under favorable conditions. These conditions include: • Warmth • Moisture • Oxygen	*What conditions promote the germination and growth of seeds?* • Grow garden seeds in the laboratory under different conditions. Note differences in growth rate.
6. Plant growth	
The conditions needed for seed germination also promote rapid plant growth. Additional factors required for plant growth include: • Light • Minerals • Carbon dioxide	Teachers may wish to review photosynthesis at this point.
Plant growth is accomplished by cell division in special growing regions of the plant. These regions are found at the tips of roots and stems, as well as in the cambium of woody stems.	Teachers may wish to relate this concept with the mitotic process.
III. ASEXUAL REPRODUCTION	
Asexual reproduction involves the production of offspring from a single parent organism. The offspring develop into individuals that are identical to the parent.	
A. Asexual Reproduction in Unicellular Organisms	
Most unicellular organisms reproduce by simple cell division. (Fission)	Show diagrams of fission in protozoa.
B. Asexual Reproduction in Animals	
Asexual reproduction is much more common in invertebrate animals than in vertebrate animals.	
1. Budding	
Budding in some animals is accomplished when cells divide rapidly in unspecialized tissues. The resulting mass of cells develops into a new living organism, which	Hydra and sponges provide examples of budding in invertebrates.

then detaches itself from the parent organism and begins an independent existence.

2. Regeneration

Regeneration refers to the replacement of lost or damaged tissues in an organism by cell division. Certain invertebrates are capable of replacing major portions of their bodies in this manner, even to the point of regenerating several new organisms from severed body parts.

Planaria, starfish, and sponges provide examples of regeneration in invertebrates.

What are some methods of asexual reproduction in animals?

- Experiment with regeneration in planaria worms. Approximately four weeks are required to allow full regeneration of severed worms.
- Observe prepared slides of Hydra with buds.

C. Asexual Reproduction in Plants

1. Vegetative propagation

In addition to reproducing by seeds, flowering plants may also reproduce by vegetative propagation. This involves the production of new organisms from the leaves, stems, or roots of the parent plant. Vegetative propagation involves cell division in unspecialized tissues of these plant parts followed by differentiation and development. Types of natural vegetative propagation include:

- Tubers
- Runners
- Rhizomes
- Corms
- Bulbs

Humans may reproduce plants by artificial vegetative propagation by the processes of:

- Cuttings
- Grafting

What are some methods of asexual reproduction in plants?

- Observe different types of vegetative propagation, e. g. , potato tubers, geranium cuttings, strawberry runners.
- Observe the spore cases of mosses or ferns. Make "spore prints" of mushrooms.

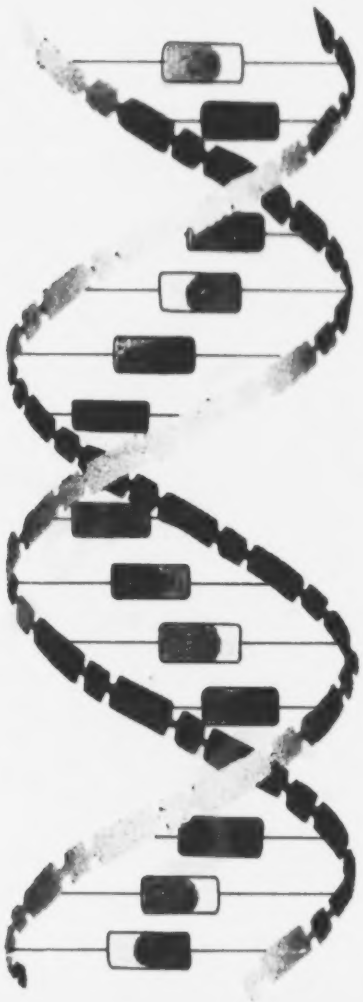
Careers:

Plant breeder
Nursery person
Horticulturist
Commercial farmer

2. Spore formation

Certain nonflowering plants reproduce by means of spores. Spores are specialized reproductive cells, each of which is capable of producing a new organism. Spores may remain inactive for long periods of time until conditions favorable for growth occur.

UNIT 5
CONTINUATION OF LIFE: GENETICS



INTRODUCTION

Maintenance of genetic continuity during the reproductive processes is the subject of this unit. The mechanisms by which the cell divides and genetic material is passed on to future generations, the patterns of genetic inheritance, and the role played by DNA in inheritance are emphasized, especially as they operate in or affect the human organism.

OBJECTIVES

Upon completion of the study of this unit, the student should be able to:

- Describe the stages of cell division.
- Distinguish between the two major forms of cell division.
- Relate the importance of chromosomes in the maintenance of characteristics of organisms.
- Identify some of the major patterns of genetic inheritance.
- Predict the genotypes and phenotypes that may result from specific genetic crosses.
- Explain the relationship between DNA and the expression of genetic traits in the cell.

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
I. GENETICS	
Genetics is the study of heredity. Heredity is concerned with the way in which traits (characteristics) are transmitted from generation to generation.	Throughout this unit, teachers may wish to review some of the major concepts included in **Units 1** and **4**.
II. REPRODUCTIVE BASIS FOR GENETICS	
As a result of reproduction and development, new organisms are produced which closely resemble their parent(s). More variation is found in offspring produced by sexual reproduction than by asexual reproduction.	
A. Inherited Traits	
In sexual reproduction, traits are transmitted through the combined genetic material found in the nuclei of sperm and egg cells (male and female gametes). In asexual reproduction, traits are transmitted through the genetic material found in the nucleus of a single parent organism.	Discuss several old ideas of inheritance (e. g., "blood lines").
B. Assurance of Genetic Continuity	
Each of the body cells of an organism normally contains the same number of chromosomes (genetic material) as each body cell in the parent organism(s).	
In asexual reproduction, this maintenance of chromosome number results from a type of nuclear division known as mitosis. In sexual reproduction, this maintenance of chromosome number results from a type of nuclear division known as meiosis, followed by fertilization.	
1. Species and chromosome number	
Each of the body cells of an organism contains a specific number of chromosomes. This number is normally the same for all members of a species and is known as the species chromosome number, or diploid number (written symbolically as 2n).	Contrast this chromosome number with that of a variety of different species. Show photomicrographs of human or other species chromosomes (karyotypes).
The human species chromosome number is 46 (2n = 46).	
In most animals, alteration in chromosome number results in abnormalities and/or death of the organism.	
2. Mitosis	Students are not required to know the details of mitotic cell division. However, teachers may wish to expand on the information given as a matter of local option.

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
a. Process All cells in the body (except sex cells) are produced by the process of mitotic cell division which includes a complex series of changes in the nuclei of body cells. These changes are known as mitosis and lead to the production of identical "daughter" cells.	*What evidence supports the concept of mitotic cell division?* • Examine prepared slides of longitudinal sections of onion root tips. Observe the various stages of the mitotic process. • Examine a film/filmstrip of cells in the process of mitosis. Discuss the process.
b. Result The process of mitosis results in the formation of daughter nuclei that exactly resemble the parent nucleus in type and number of chromosomes. In addition to its function in producing offspring during asexual reproduction, mitotic cell division also accomplishes growth and repair of body tissues in multicelled organisms.	Discuss abnormal cell division in cancer cells. Show photographs or films of protozoans in mitotic division.
3. Meiosis	Students are not required to know the details of meiotic cell division. However, teachers may wish to expand on the information given, as a matter of local option.
a. Process Sex cells of animals are produced by the process of meiotic cell division which includes a complex series of changes in the 2n nuclei of cells generally located in sex organs. These changes are known as meiosis and lead to the production of eggs and sperm.	Human eggs have already entered meiosis at birth and remain for 12 to 45 years before completing the process. Crossing over, which results in new random combinations of genes, occurs during meiosis, producing new variations in offspring. Illustrate this concept by means of paper models of chromosomes on an overhead projector.
b. Result Sex-cell nuclei contain one-half the number of chromosomes found in normal body cells of a species. This number of chromosomes is known as the monoploid number (written symbolically as n). In humans, the monoploid number is 23 (n = 23).	
4. Fertilization	Continue the illustration above, using paper cutouts to illustrate the events of fertilization.
a. Restoration of species chromosome number When a sperm cell and an egg cell fuse during fertilization, their nuclei also fuse. The fusion of these two monoploid nuclei produces a zygote with a diploid nucleus. Thus, fertilization restores the species chromosome number which was halved in meiosis (n + n = 2n). The zygote then divides repeatedly by mitosis (cleavage) to form the embryo. These early mitotic divisions are known as cleavage. Each embryonic cell contains the 2n number of chromosomes.	

UNDERSTANDINGS	ACTIVITIES AND TEACHER NOTES
b. Combination of parental traits Since the zygote contains information from each parent, it develops into an organism which may express traits of both parents, but it will have a different combination of traits than either parent.	
III. FOUNDATIONS OF GENETICS Starting with the 19th century, much research has been done in the field of genetics. This work indicates genetic studies by Gregor Mendel, followed by the development of the gene-chromosome theory.	Although Mendel did not use the term "gene," he did recognize that specific factors responsible for traits were passed from parents to offspring.
A. Classical Genetic Studies In the mid-nineteenth century, Gregor Mendel performed investigations into the mechanisms of heredity. His studies involved traits found in the common garden pea. Statistical data collected by Mendel made it possible for him to develop several hypotheses concerning the way in which traits are passed from generation to generation. Much of Mendel's work remains the basis for modern genetic theory.	
B. Gene-Chromosome Concept A genetic theory which uses Mendel's basic ideas, but adds much new knowledge about the cell and its workings is known as the gene-chromosome theory.	"Pop beads" may be used to illustrate the gene-chromosome concept.
1. Chromosomes and genes Chromosomes (found in the nucleus of the cell) contain certain portions, known as genes, that are associated with specific traits. Each chromosome may contain several hundred genes.	
2. Gene inheritance During fertilization, both the male and the female parent contribute genetic information on chromosomes to the formation of the zygote. For traits which are controlled by a single pair of genes, one gene of the pair is contributed by the male parent, the other by the female parent.	
IV. GENETIC PATTERNS Through the work of Mendel and many others, several patterns of genetic inheritance have been recognized and described.	Students should be familiar with the "Punnett Square" technique of predicting the results of genetic crosses.

UNDERSTANDINGS	ACTIVITIES AND TEACHER NOTES
A. Dominance/Recessiveness	
1. Definition When an organism, pure for a trait, is crossed with an organism, pure for the contrasting trait, all their offspring will show one of these traits. The one expressed is known as the dominant trait, and this pattern of inheritance is known as dominance.	
a. Dominant genes For traits which are controlled by a single pair of genes, the gene that masks the effect of the other gene is known as the dominant gene. Dominant genes are normally represented by a capital letter in genetics problems. Dominant genes show their effects when both members of the gene pair are dominant (pure dominant condition), or when a dominant gene is paired with a recessive gene (hybrid condition).	*How do mathematical laws aid the study of genetics?* • Illustrate the laws of probability by tossing coins and collecting data. A large number of tosses may be simulated by using a BASIC computer program. • Illustrate Mendelian inheritance in pea plants by use of the Punnett Square. Students should be familiar with the terms P1, F1, F2 genotype, and phenotype.
b. Recessive genes The gene which is masked by a dominant gene is known as a recessive gene. Recessive genes are normally represented by the lower case of the letter used to designate the dominant member of the gene pair in genetics problems. Recessive genes show their effects only when both members of a gene pair are recessive (pure recessive condition).	*What experimental evidence supports genetic theory?* • Grow hybrid corn seeds to illustrate the results of monohybrid crosses (green: albino). • Observe the ratios of phenotypes of fruit fly crosses involving simple dominance.

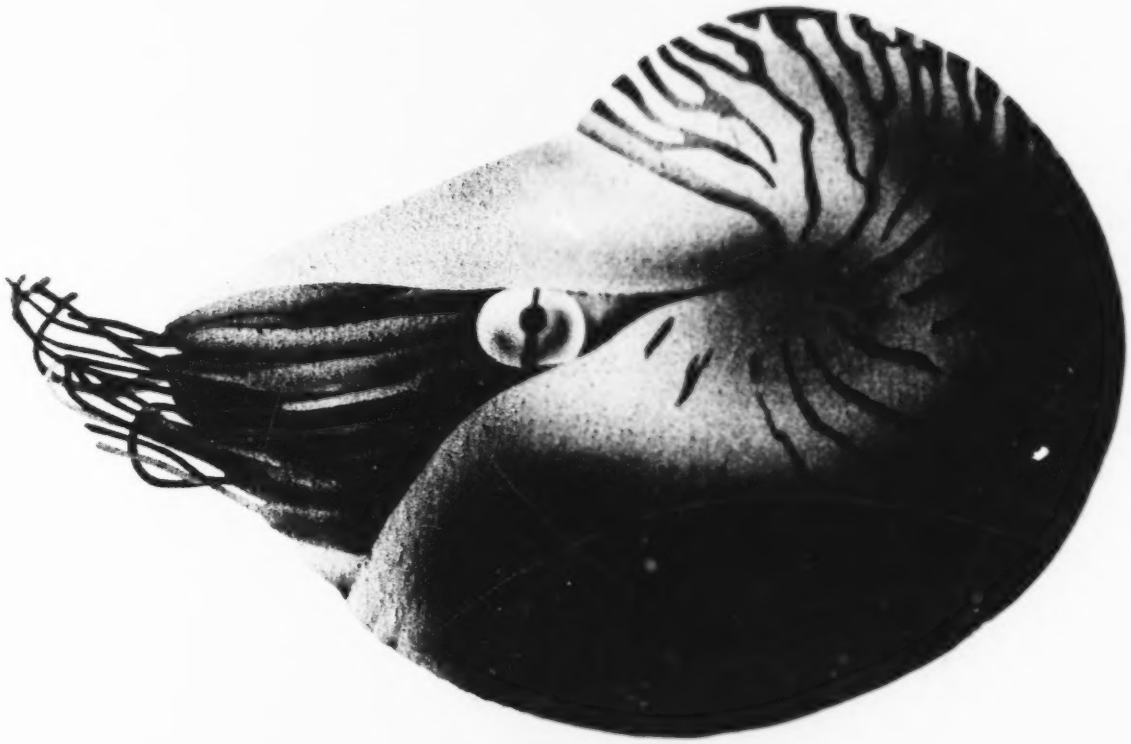
UNDERSTANDINGS	ACTIVITIES AND TEACHER NOTES
2. Examples Several examples which show the pattern of dominance include: • Stem length in garden peas (tall and short) • Seed shape in garden peas (round and wrinkled) • Tongue-rolling in humans (rollers and non-rollers) • PTC-tasting in humans (tasters and non-tasters)	*What patterns of inheritance may be studied in the classroom?* • Collect class data on the number of tongue-rollers. • Construct family pedigree charts to trace the inheritance of a trait. Use this data to confirm the pattern of inheritance. • Study other traits such as ear lobes, eye color, dimples, and big toe length. *How can the results of genetic crosses be predicted?* • Use "Punnett Squares" to predict the inheritance of traits in plants and animals. Work out genotype and phenotype ratios. Students should be familiar with pedigree charts and how they are used to trace traits in families.
B. Sex Inheritance and Sex Linkage	
1. Definition Maleness and femaleness in many organisms, including humans, is determined by the combination of a special pair of chromosomes known as the sex chromosomes, X and Y. The Y chromosome is smaller than the X chromosome and lacks several of the genes found in the X chromosome. Egg cells contain only one kind of sex chromosome, the X, while sperm cells carry either an X or Y chromosome. As a result of fertilization, only two combinations of the X and Y chromosomes are normally possible. The combination XX produces a female and the combination XY produces a male.	Emphasize that the Y chromosome can lack genes found on the X chromosome.
In males, a recessive gene on the X chromosome may be expressed if no corresponding gene exists on the Y chromosome to mask it. In females, a dominant gene found on the one X chromosome normally masks any such recessive gene which may be found on the other X chromosome. Genes located on sex chromosomes are known as sex-linked genes.	Illustrate the inheritance of hemophilia by examining pedigree charts (e.g., descendants of Queen Victoria of England). Career: Genetic Counselor
2. Examples Examples of sex-linked inheritance include: • Hemophilia in humans • Color-blindness (red-green) in humans	

UNDERSTANDINGS	ACTIVITIES AND TEACHER NOTES
C. Other Patterns of Inheritance Many other patterns of inheritance exist which do not follow the mechanisms of simple dominance or sex linkage.	Teachers may wish to discuss other patterns of inheritance of particular local interest not included here (e. g. , blood type inheritance).
V. GENETIC PATTERNS AND THE ENVIRONMENT Most characteristics of an organism result from the interaction between the organism's genes and the environment. Examples of the interaction between the environment and genes include: • Influence of light on chlorophyll production • Influence of diet on human size.	
VI. CHEMICAL BASIS FOR GENETICS **A. Genes** Genes are composed of a chemical compound known as DNA (deoxyribonucleic acid)	
1. Structure of DNA DNA is a large, complex molecule found in high concentrations in cell nuclei. DNA is a long chain of units known as nucleotides. In DNA there are four different kinds of nucleotides.	Students are not responsible for the details of DNA structure. However, teachers may wish to show students models or diagrams of DNA's structure, and/or detail the base pairs common to DNA, as a matter of local option.
2. Function of DNA • DNA makes exact copies of itself (replicates) and these copies are passed from the parent cell to daughter cells during cell division. • DNA also controls the manufacture of enzymes which, in turn, control cellular activity.	
Genetic information is present in the structure and organization of DNA. This information depends upon the arrangement of the different nucleotides in the DNA molecule (the genetic code).	The following example might be used to relate DNA code to the alphabet code: Alphabet — DNA Code letters — nucleotides words — three nucleotides sentences — genes chapters — chromosomes book — nucleus
Special chemical molecules known as RNA messengers, carry the genetic code information of DNA from the nucleus to ribosomes in the cytoplasm of the cell.	Students are not responsible for understanding DNA function in greater detail than is presented in the "Understandings" column. Teachers may wish to treat information in greater depth, as a matter of local option.

UNDERSTANDINGS	ACTIVITIES AND TEACHER NOTES
At the ribosomes, the messengers, because of the specific information they carry, direct the making of specific proteins known as enzymes which control specific cellular processes.	Specific enzymes control specific reactions and thus specific traits.
It is through this mechanism of enzyme production that genes control genetic traits.	
B. Changes in Genetic Information	
1. Mutations	
If the genetic code of DNA is altered in any way, an incorrect message may result. Such alterations are known as mutations. Mutations are potentially harmful because they may disrupt normal cell functions.	Examples of conditions resulting from mutations include: seedless oranges, sickle-cell anemia, albinism, and hemophilia.
Mutations include any change in chromosome composition (DNA structure-position) or chromosome number.	
2. Mutagenic agents	
Mutations may occur due to a variety of causes, including some which operate normally within the cell. External causes of mutation include radiation (X-rays, gamma rays) and chemicals (benzopyrene, colchicine).	Students should be made aware of the dangers present to unborn children exposed to mutagenic agents *in utero*. Career: Genetics Lab Technician. Discuss how nutagenic agents cause mutations.
C. Genetic Engineering	
1. Definition	
Recent research in genetics in which scientists deliberately remove genes from one organism and add them to the genetic material of another organism is known as genetic engineering. The added genes may be expressed by the cells that now contain them.	Have students read and discuss articles on current research in genetic engineering.
2. Benefits/Drawbacks	
Genetic engineering has greatly increased our ability to treat certain genetic-related disorders such as diabetes.	Discuss other pros, cons, and the implications of manipulating DNA.
There is concern, however, that genetic engineering may lead to the production of new forms of life potentially dangerous to humans and other organisms.	

UNDERSTANDINGS	ACTIVITIES AND TEACHER NOTES
3. Examples	
a. Biochemical production	
Scientists have spliced genes for the production of certain biochemicals into the chromosomes of certain bacteria. The altered bacteria are then able to produce the biochemical in large quantities, forming an inexpensive, reliable source of the biochemical. Biochemicals produced in this way include insulin and interferon.	Use DNA models to illustrate how DNA can be split and how new sections of DNA can be spliced in. Discuss the role of *E. coli* in genetic engineering.
c. Cancer research	
Scientists studying cancer have already used genetic engineering techniques to demonstrate the genetic link to certain types of cancer. By removing small sections of particular genes, they have been able to pinpoint the location of genes which have the potential to cause cancer.	Research has indicated the presence of cancer-causing genes known as oncogenes. These oncogenes are linked to the occurrence of particular types of cancer.

UNIT 6
EVOLUTION AND CLASSIFICATION



INTRODUCTION

This unit contains a brief survey of organic evolution including: a theory for the origin of life on earth; some of the observations in support of evolution; some of the theories of evolution that attempt to explain the evolutionary processes; and human evolution.

Classification systems which are used to organize the great variety of living things that resulted from the evolutionary process, the need for classification systems, and the criteria used in classification are also included in this unit.

OBJECTIVES

Upon the completion of the study of this unit, the student should be able to:

- Define organic evolution.
- Recognize the problems involved in determining the age of the earth and its fossils.
- Recognize the problems involved in formulating theories for the origin of life.
- Identify observations which support evolution.
- Contrast the theories of evolution of Charles Darwin and Jean Lamarck.
- Explain modern theories of evolution that have grown out of new research.
- Recognize that humans may have evolved from ancestral organisms.
- Classify organisms according to the Linnaean system of classification.

UNDERSTANDINGS	ACTIVITIES AND TEACHER NOTES
I. ORGANIC EVOLUTION Evolution is a process of change through time. It involves the study of the: • Origin of life. • Development of complex organisms from simpler forms of life. • Theories that explain how organisms may have changed over long periods of time.	Use a diagram or photo of an evolutionary tree which shows the start of life from chemical origins followed by the evolution of organisms leading to the forms of life that exist on earth today. Point out that the study of evolution may reveal the common origin of these diverse forms of life on earth.
A. Origin of Life Various hypotheses have been proposed by the scientific community to explain the events involved in the origin of life.	
1. Age of the earth Recent research reveals the earth to be more than 4. 5 billion years old. Dating by radioactive methods has been used to determine the age of the earth's rocks. Where the crust of the earth is undisturbed, the oldest rock layers underlie the younger layers.	Show pictures of the rock strata of the Grand Canyon. Discuss sedimentation and indicate which rock layers are the oldest. Use a calendar where 1 year = 12 billion years to explain enormous time periods. Indicate in the calendar when life first appeared.
2. First living things Recent experimental data indicate that life began in or near the ocean from groups of organic molecules that were formed from the chemical elements in the Earth's primitive atmosphere.	*How can molecular aggregation be simulated?* • Add a preparation of 5 ml. of 1% gelatin solution and 3 ml. of 1% gum arabic solution to a test tube. Next, while stirring, add 0. 1 molar HCl drop by drop until the solution becomes cloudy. Place a drop of the cloudy solution on a slide and observe under a compound microscope. Look for aggregates.
The first living things may have resembled modern anaerobic bacteria. Since no free oxygen gas existed in the atmosphere, these forms of life carried on anaerobic respiration. They utilized the free organic molecules in the sea for food.	Show photos and diagrams of simple unicellular organisms. Relate these examples to the first life forms that may have evolved. Career: Geologist
Genetic changes in the first organisms contributed to the evolution of photosynthetic forms of life which could produce food and release oxygen into the atmosphere. Eventually aerobic forms of life (utilizing atmospheric oxygen for aerobic respiration) evolved from the anaerobic forms.	

UNDERSTANDINGS	ACTIVITIES AND TEACHER NOTES
Evolution is a continuing process and the organisms that exist today appear to have evolved directly or indirectly from the first primitive forms of life.	Examples of recent changes in organisms include bacterial resistance to antibiotics and insecticide resistance in insects. Show filmstrips/films on the origin and evolution of life.
B. Supporting Evidence for Evolutionary Theory Certain observations reveal chemical and structural relationships among organisms. These observations support the theory that complex organisms have evolved from simpler forms over long periods of time.	
1. Comparison of skeletons Skeletons of vertebrates have similar basic structure. This observation indicates that organisms with similar bone structures evolved from a common ancestor population.	Show photos, specimens, or 2 x 2 slides of vertebrate skeletons. Indicate similarities in the bones.
2. Comparison of embryos The structural similarities among vertebrate embryos provide evidence that indicate a close relationship and common ancestry among the vertibrates.	Show photos or specimens of various vertebrate embryos and indicate similarities.
3. Comparison of cells Organisms are composed of cells having organelles that are similar in structure and function. These structural and functional similarities provide evidence for common ancestry.	Review common cellular organelles from **Unit 1**.
4. Comparison of chemicals in living things Similarities in the biochemistry (body chemicals) of living things (DNA, hormones, and enzymes) indicate a close relationship between various forms of life.	Compare hormones and enzymes in vertebrates.
5. Presence of vestigial structures Vestigial structures are small, apparently functionless structures that strongly resemble structures which are more fully developed and functional in other animals. Vestigial structures such as the appendix in humans and leg bones in a python provide evidence of changing structure and function.	Many vestigial structures can be discussed; e.g., leg bones in porpoises and ear muscles in humans.

UNDERSTANDINGS	ACTIVITIES AND TEACHER NOTES
6. Study of fossils	
The study of fossil distribution in the earth provides evidence to support the concept that life developed from the simple to the complex. It shows the apparent transition of life from sea to land, helps provide evidence for the time of origin of various forms of life, and helps provide evidence of changing climate and land surfaces.	*What are fossils?* • Examine a variety of fossil types and note how they were fossilized. • Produce simulated fossil imprints, casts, and molds in plaster of paris.
A fossil is any sign of earlier life. Examples of fossils ininclude: whole preserved organisms in amber, tar, or ice; preserved hard parts of organisms; imprints; and fossil fuels.	Show specimens preserved in plastic and compare to amber preservation. Radioactive dating techniques are used to date fossils. Careers: Paleontologist Museum Curator Geologist
C. Early Theories of Evolution	
Theories of evolution help to explain how the processes of evolution take place. In the 19th century Jean Lamarck and Charles Darwin proposed explanations of the evolutionary process.	Lamarck's theories are generally discarded today since they lack supporting evidence. Mention should be made of Weismann's experiments disproving the theory of inheritance of acquired characteristics.
1. Lamarck's theory	
The explanation for evolution proposed by Lamarck included the concepts of:	
a. Use and disuse	
New organs arise according to the needs of an organism and the size of organs is determined by the degree to which they are used.	
b. Inheritance of acquired characteristics	
Useful characteristics acquired by an individual during its lifetime can be transmitted to its offspring.	The fact that clipped tails or ears in dogs, bound feet in some Oriental cultures, and enlarged human lips (produced by inserting discs) in certain African cultures do not recur in offspring further disputes Lamarck's theory.
2. Darwin's theory of natural selection	
The theory of natural selection proposed by Darwin attempted to explain gradual change in species through natural selection. Natural selection implies that traits which promote survival in a changing environment are passed on to the next generation.	Alfred Wallace, working independently of Darwin, proposed a theory of evolution that is quite similar to the theory of natural selection.
Some of the concepts included in the process of natural selection are: overproduction, inherited variation, struggle for survival, survival of the fittest, and evolution of new forms of life.	

UNDERSTANDINGS	ACTIVITIES AND TEACHER NOTES
a. Overproduction Within a population, more offspring are produced than can possibly survive.	Illustrate overproduction by relating to spore formation in puffballs, seed production in dandelions, and egg production in fish.
b. Variations Differences in structure, and color (variations) occur among members of an actively reproducing population.	*How are variations in populations studied?* • Observe the variation that exists within a population by measuring the length of seeds, height of plants, or number of segments in earthworms. The genetic basis for variations might be reviewed here. Darwin was unable to explain the causes of variation.
c. Struggle for survival Organisms compete with each other for various requirements necessary for their survival. Examples of these requirements for life may include food, water, light, minerals, and reproductive sites.	*How can you observe competition?* • Plant varying numbers of seeds such as 20-100 in increments of 20, 40, 80, 100 in separate pots of the same size and maintained under identical conditions. After germination, count and graph the percentages of survivors. Compare the characteristics of survivors in each group. Discuss protective coloration and mimicry.
d. Survival of the fittest The individuals which survive are the ones which tend to be best adapted to exist in their environment due to the possession of favorable variations. An adaptation is a structure/function that enables an organism to live and successfully reproduce in a particular environment.	Discuss the English peppered moth as an example of adaptation to a changed environment. *What is favorable variation?* • Scatter an assortment of small, colored toothpicks in a grassy spot. Students (predators) should try to retrieve as many as they can within a certain time period. Note how many *green* toothpicks "escape" due to a successful adaptation.
e. Evolution of new forms The individuals that survive will most likely pass their favorable variations to their offspring. Over long periods of time, as a result of the accumulation of these variations, a new species may evolve.	Display pictures of varieties of organisms developed by humans through selection. By artifical selection, humans simulate, in a greatly reduced time, what may happen in nature over much longer periods.
D. Modern Theories Studies of mutations, sexual reproduction, and geographic isolation have been used to further develop evolutionary theory.	
1. Mutations Mutations (changes in genetic material) result in variations which may give offspring a better chance for survival.	Mutations are treated in greater detail in **Unit 5.** Discuss resistance to: insecticides in flies, antibiotics in bacteria, and malaria in humans with the sickle-cell trait.

UNDERSTANDINGS	ACTIVITIES AND TEACHER NOTES
2. Sexual reproduction Sexual reproduction results in new combinations of genes which produce variations that may have adaptive value.	The concept of sexual reproduction is treated in greater detail in **Unit 5**.
3. Geographic isolation Geographic isolation occurs when a population is physically separated into smaller populations by mountain ranges, deserts, or bodies of water. Changes may occur in these separated populations which, over a long period of time, may result in the production of different species.	Discuss the theory of how the Kaibab and Abert squirrels of the Grand Canyon developed from a single ancestral species due in part to isolation.
E. Human Evolution Evidence indicates that humans, like other living things, may have evolved from ancestral organisms.	The ape and the human appear to have evolved from a common ancestor.
1. Problems in studying human evolution Human evolution is not completely understood principally because of the scarcity of fossils. The exact place in human ancestry of the variety of human-like fossil forms which have been discovered has yet to be determined.	Discuss the conditions needed for good fossil formation and some of the problems involved in locating human fossils. Point out that the search for human fossils is a relatively recent activity among scientists. Discuss some of the work of the Leakeys and Donald Johanson in Africa. Careers: Archaeologist Anthropologist
2. Characteristics unique to humans Certain characteristics have helped the human to evolve as a dominant force on Earth. Among these are: • A superior brain which enables humans to reason, speak, and use tools. • A prehensile grip which facilitates the manipulation of tools, pens, and other implements. • An upright posture which frees two limbs for involvement in activities other than support and locomotion.	Mention the problems resulting from the evolution of an upright posture: lower back pain and difficulties at birth caused by a large head and a modified pelvis.
3. Future of human evolution It is assumed that human evolution, like evolution in other animals, is continuing. However, due to superior reasoning ability, humans are able to modify their environment. Therefore, the evolutionary effect of natural selection is not as great as in other organisms. Factors which affect or may affect human evolution include:	

UNDERSTANDINGS	ACTIVITIES AND TEACHER NOTES
a. Medical knowledge	
Medical knowledge permits the survival of individuals with genetic traits such as diabetes, hemophilia, and PKU thus maintaining or increasing the frequency of the genes for these traits in the human gene pool.	PKU (Phenylketonuria) – a recessive genetic disorder of humans that results in brain damage.
b. Modern transportation	
Due to modern transportation, humans are less affected by the evolutionary force of geographic isolation.	Discuss the result of geographic isolation among humans, e.g., aborigines in Australia and New Guinea.
c. Advanced technology	
Advanced technology has given humans better nutrition, greater control over the reproductive process, and has increased the number and kinds of mutagenic agents in the environment.	The impact of technology on human survival is also treated in **Unit 7**.
d. Genetic engineering	
Genetic engineering may possibly lead to the appearance of new traits and the elimination of others.	Genetic engineering is treated in detail in **Unit 5.**
II. CLASSIFICATION	
Evolution has produced a wide variety of living organisms. Various systems of classification have been devised to group these organisms.	
A. The Need for a Classification System	
Classification systems help group living things in such a way as to make it easier to study them. These systems help reveal evolutionary relationships and patterns among organisms.	Discuss how difficult it would be to find a book in the library if there were no classification system.
Most classification systems are based on the notion that present-day forms of life developed from earlier forms.	*How do classification systems work?* • Classify a group of paper objects by shape, color, size and texture. Note how many different classification systems can be devised. Point out how some people classify clothing in the drawers of a dresser or the classification system we use to determine where a person lives.
B. Basis for Classification	
Structural similarities are used as a major classification criterion. These structures may be gross external structures (exoskeleton, appendages), internal structures (organs, skeleton), or cellular structures (chloroplasts, nuclei).	Include other classification criteria such as fossil record, life-cycle characteristics, embryonic development, and chemical similarities. Discuss why habitat or color are not used extensively as classification criteria.

UNDERSTANDINGS	ACTIVITIES AND TEACHER NOTES
C. Classification Groups	
A grouping system into which organisms are separated into smaller and smaller subgroups based on common characteristics was devised by Carolus Linnaeus, a Swedish naturalist in the eighteenth century.	The Linnaean system works much like an address: Kingdom – United States Phylum – New York State Class – Adamsville Genus – Stove Pipe Road Species – House #4
The Linnaean classification groups include:	Students are not responsible for the subgroups, Order and Family. Careers: Taxonomist Museum Curator
1. Kingdom	
The kingdom is the largest group containing the greatest number of different organisms. Most biologists now group organisms into a five-kingdom system: • Animal (multicellular organisms that ingest their food) • Plant (multicellular, photosynthetic organisms) • Fungi (nonphotosynthetic, cells with cell walls) • Protista (mainly unicellular plant-like or animal-like organisms) • Monera (primitive cells lacking a nuclear membrane) There are many systems of classification and some disagreement as to which most accurately groups related organisms.	Refer to **Unit 3** for examples and characteristics of organisms belonging to the five kingdoms. Briefly discuss one representative organism of each kingdom. Show pictures, models, specimens. *How do you distinguish organisms in the five kingdoms?* • Observe examples of organisms belonging to the five kingdoms. Compare their characteristics.
2. Phylum	
The phlyum is the major subgroup of the kingdom.	Point out some basic structures and characteristics that determine classification in a particular phylum, e.g., arthropods (exoskeleton, jointed appendages, and segmented bodies).
3. Class	
The class is a subgroup of the phylum.	Point out some basic structures and characteristics that determine classification in a particular class; e.g., birds are warm-blooded and have feathers.
4. Genus	
The genus is a group of closely related species.	Illustrate with the cat genus: *Felis leo* – lion *domestica* – house cat *tigris* – tiger
5. Species	
The species is a subgroup of the genus which contains similar organisms that have the ability to mate with each other and produce fertile offspring. A species consists of only one type of organism.	

UNDERSTANDINGS	ACTIVITIES AND TEACHER NOTES
D. Scientific Names vs. Common Names	
Organisms are given Latin scientific names that are accepted worldwide.	Discuss why Latin is used for scientific naming.
Scientific names consist of the genus and species names of the organism and are usually written in this manner: *Genus species,* e.g., *Homo sapiens.*	Examples of scientific names are: *Canis familiaris* (dog) *Hyla Crucifer* (spring peeper) *Acer saccharum* (sugar maple)
Common names are local names given to an organism in a certain geographic region. These names can be confusing as there may be more than one common name for the same organism.	Use woodchuck, ground hog, and gopher as examples of common names for the same organism.
Common names may be misleading since they often contain a word which does not correctly describe the organism.	Neither the starfish nor the silverfish is a fish.
E. Human Classification	*How are classification keys used?*
Humans are classified as: • Kingdom: Animal • Phylum: Chordata • Class: Mammals • Genus: *Homo* • Species: *sapiens*	• Classification keys are used to help identify an organism with its proper classification group. • Use a simple key to classify/identify a group of organisms by common name or kingdom or phylum.
All present day humans are classified as one genus and species: *Homo sapiens.*	

UNIT 7
LIVING THINGS AND THEIR ENVIRONMENT

INTRODUCTION

Previous units in this syllabus have presented the structures and functions of living things as though they were largely independent of one another. This unit attempts to show that organisms and their life processes are interdependent in nature. The concept of interaction among organisms and the nonliving environment is presented, as well as factors that affect human populations and the impact of humans on the environment.

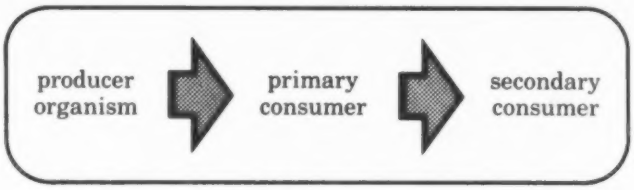
OBJECTIVES

Upon completion of the study of this unit, the student should be able to:

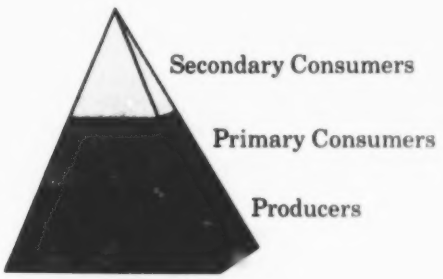
- Identify the major subdivisions of environmental organization.
- Describe the interactions which exist within major environmental subdivisions.
- Describe the human population in terms of its relationship to the environment.
- Relate how the need for a clean environment requires careful conservation of resources.

UNDERSTANDINGS	ACTIVITIES AND TEACHER NOTES
I. ECOLOGY Ecology is the study of the interactions of organisms with their living and nonliving environments.	Teachers should present ecology as a study in biology that requires a knowledge of similarity and diversity of living things, life functions, types of reproduction, patterns of inheritance, and natural selection. Careers: Environmental Engineer Forester Conservation Officer
II. **RELATIONSHIPS IN THE ENVIRONMENT**	
A. Ecosystem The term ecosystem refers to the living and nonliving factors that interact in a region. It is a basic unit used by ecologists in the study of the environment. Examples of ecosystems include balanced aquaria, ponds, vacant lots, woodlots, salt marshes, and forests.	
1. Living factors in the ecosystem Living Factors include: • Producers (plants) – manufacture food by photosynthesis. • Consumers (animals) – eat the producers and/or eat other animals. • Decomposers (bacteria and saprophytic fungi) – break down dead organisms and make their components available to other living things.	Relate the characteristics of living factors presented here with the survey of living things presented in **Unit 2**. *What ecological factors may be observed in an ecosystem?* • In small groups, closely examine the producer organisms in a defined environment (vacant lot, aquarium, etc.) Catalog and group the types present. • Examine a box containing moist soil. List the factors present in the box. (When the box is open, all essential nonliving environmental factors are present; when closed, light is not present.) • Bury an empty can in the ground, its open top even with ground level. Examine the contents each day for several days. Catalog and group types of animals trapped. • Examine a rotting log as an example of an ecosystem. • Construct a balanced aquarium as a laboratory project. • Discuss a specific example of interactions within an ecosystem such as cycling (carbon/oxygen cycle, nitrogen cycle, water cycle).

UNDERSTANDINGS	ACTIVITIES AND TEACHER NOTES
2. Nonliving factors in the ecosystem Nonliving factors include: • Soil – plants and some animals live and grow in the soil which provides minerals for healthy growth. • Water – needed by all living things for their normal functioning. • Air – composed of gases used in the processes of photosynthesis and respiration. • Energy – exists in various forms (light, heat, motion, chemical bonds, etc.) and is used by all living things in their life processes.	
B. Communities A community includes all the different species interacting in an ecosystem.	*What are the characteristics of a community?* • Take a field trip to a local ecosystem to observe species interacting in a community. Teachers should give several local examples of community interactions.
1. Interactions in a community	
a. Nutritional interactions in a community Nutritional interactions include food chains and webs. A food chain involves the transfer of food materials from producer to consumer, and from one consumer to the next. The general pattern for a food chain is as follows:	Students should be able to recognize several different examples of organisms that could be included in typical New York State food chains and webs. Students should be able to interpret diagrams of food chains and webs.



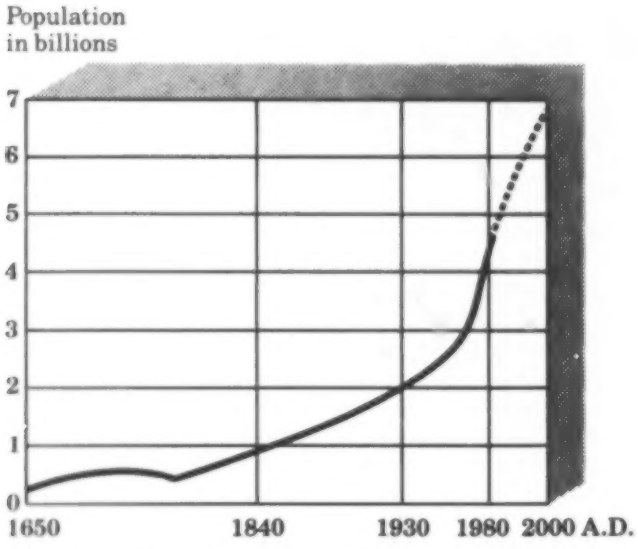
The many interacting food chains in an ecosystem form food webs.	*What nutritional relationships exist in a natural environment?* • Construct "food webs" by pasting cutout pictures of organisms onto cardboards. Use strings to connect each pair of organisms for which a nutritional link exists. Observe the resulting "web" of interaction. • Identify natural food chains of local importance. Discuss the result, if any, if the nutritional levels were eliminated.
Primary consumers (herbivores) are animals which eat plants. Secondary consumers (carnivores) are animals which eat other animals. These include predators which kill and eat their prey and scavengers which feed on dead animals they find.	

UNDERSTANDINGS	ACTIVITIES AND TEACHER NOTES
b. Energy interactions in a community	
A vital use of food is for energy. At each step of a food chain, energy is transferred to the next higher level (from producer to primary consumer or from primary consumer to secondary consumer).	Energy content of foods is treated in greater detail in **Unit 2.**
This energy transfer, however, is inefficient since much of the food energy taken in by a consumer is used in the processes of metabolism. Energy is "lost" at each food exchange and therefore, less energy is available to the higher levels of the food chain than to the lower levels.	Only about 10 percent of the energy entering one consumer level of a food web is available to the next level (depending on local conditions).
This concept is often represented by a "food pyramid" or "energy pyramid" as follows:	
	
c. Other interactions in a community	
• Symbiosis – a close association between organisms of different types in which at least one member of the association is benefitted by the association. Examples of symbiotic relationships include mutualism, commensalism, and parasitism.	*What symbiotic relationships may be observed in the environment?* • Observe lichens growing on rocks or tree trunks (mutualism). • Observe nodules of nitrogen-fixing bacteria on the roots of clover plants (mutualism). • Observe preserved parasites; discuss parasite-host relationships (i. e., tape worms in the digestive tract of a human). • Examine photographs or media showing commensalistic relationships (i. e., barnacles attached to the body surface of a whale).
• Competition – the struggle among organisms utilizing the same limited resources.	*How may interspecies competition be observed?* • Plot sample quadrants one meter square on the school lawn. Count and map dandelion and/or plantain plants. Estimate total area covered vs. grassed areas. Calculate population densities.
2. Community dynamics	
a. Stable communities	
In an ecosystem, if environmental conditions remain stable over long periods of time, the species of plants and animals which make up that ecosystem continue to live	

UNDERSTANDINGS	ACTIVITIES AND TEACHER NOTES
and interact there, generation after generation. These species of plants and animals then make up a stable community (climax community).	
b. Changing communities	
Under conditions of environmental change, some species may be replaced by other species. Such gradual replacement of species is known as "ecological succession."	Examples of environmental changes include clearcutting, storm damage, vulcanism, and fire.
Succession generally leads to the establishment of a climax community.	Illustrate the concept of succession with local examples (e. g., pond, lake shore, salt marsh, woodlot). *How can ecological succession be observed?* • Examine the plant life at the edge of an abandoned field. Note the overlapping bands of field and forest plants. Map and catalog species types and densities. • Predict the time required for a field to revert to forest based on above data.
C. Populations	
All the interacting individuals of the same species in a limited geographic area make up a population.	
1. Interactions within a population	
The interactions that occur within a population may include those associated with individual or group survival. Food-getting, territorial defense, or reproductive behavior are examples of such interactions within populations.	
2. Population dynamics	
a. Stable populations	
Under stable environmental conditions, the number of organisms in naturally occurring populations remains constant, with only small periodic changes.	Use examples of local relevance (e. g. , mouse/owl population swings).
A population's size is kept in check by a variety of limiting factors which reduce the increase expected through reproduction. Limiting factors may include: food resources, water resources, disease, predation, and living space.	
b. Unstable populations	
• **Endangered and extinct populations**	
Through a combination of natural and human interactions, some species have been drastically reduced in number. Many such species are classified as "endangered," meaning that without some form of human protection, the entire species may completely disappear (become extinct).	Endangered or extinct animal species of local relevance should be included.

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
Examples of endangered species are the blue whale and timber wolf. Examples of extinct species are the great auk and the passenger pigeon.	
• **Exploding populations**	
Occasionally, conditions may temporarily favor the rapid reproduction of a species, leading to a population "explosion." Such explosions are usually followed by a rapid decline in population due to limiting factors. Examples of exploding populations include algal "blooms" in lakes, Kaibab deer of the early 1900's, and gypsy moth populations.	*How can population growth be studied in the laboratory?* • Grow bacteria under controlled conditions in the laboratory. Observe the growth and decline of cultures. • Set up a gallon jar with pond vegetation, some pond mud, and water. Observe population diversity and changes over several weeks. Discuss human population increase (see next section) as an example of population explosion.
III. THE HUMAN POPULATION	
A. Our Requirements as Individuals	
We must have certain requirements in order to maintain our lives as individual organisms. These requirements include: • Clean air • Clean water • Nutritious food • Fertile soil • Shelter/living space	Emphasize that any one of these requirements is reduced in value when polluted. Stress that no matter where we live, a certain amount of land must be available to grow the food that we consume. *How do soil conditions affect plant growth?* • Grow garden seeds such as corn or beans in two types of soil ("enriched" and "depleted" soils). Observe differences in growth rate. • Vary other soil conditions in the same type of experiment (e. g., humus vs. sand, gravel vs. clay).
B. Requirements of Species	
We require the following in order to maintain our existence as a species.	
1. Interaction with other life forms	
We interact with many different forms of life. Although we are not aware of many of these interactions, they are nevertheless important to our survival. These interactions may provide us with food, clothing, oxygen, or other requirements.	Give examples of organisms with which we interact. Include some for which the interaction is not obvious. Examples: English sparrows live independently of humans, but survive better if human habitations are present to provide nesting space.
We, in turn, affect the lives of other organisms. Some organisms depend on our presence for their survival. Others may be affected negatively by our activities.	Mayflies do not interact directly with humans, but provide an important food source for game fish. Discuss organisms that have been affected adversely by the activities of humans (e. g. , whales, whooping cranes, bald eagles).

UNDERSTANDINGS	ACTIVITIES/TEACHER NOTES
2. Interaction with nonliving factors	
The nonliving environment provides us with many essential components upon which our survival depends.	
Our activities are increasingly altering the nonliving environment. The burning of coal and oil has added oxides of carbon, sulfur, and nitrogen to the air in significant quantities. Water and soil are similarly affected. Mineral resources of many types are becoming scarce as they are used in our technologies and agricultural practices.	The phenomena of "acid rain" (acid deposition) and the "greenhouse effect" may be used as examples of the alteration of environment by humans.
The way in which we alter our physical environment will ultimately determine the survival of all living things, including that of our own species.	
C. Population Growth	
1. History	
Unlike that of naturally occurring species, human population growth is not stable. Our population around the world is growing rapidly and has been doing so for the past two centuries. This population growth may be illustrated using a graph:	*How can the growth rate of the human population be predicted?* • Plot "future growth" of the human population by extrapolating population data for the past 1,000 years. • Use an interactive computer simulation of population growth to examine how we may direct our own future growth. Career: Demographer



World Population of Humans

UNDERSTANDINGS	ACTIVITIES AND TEACHER NOTES
2. Implications There are both positive and negative implications of the growth in the human population. However, some scientists estimate that we are rapidly approaching the limits of our ability to increase as a species, due to limiting facotrs such as the availability of food, clean water, and clear air.	
IV. Human Impact on the Environment	
A. Environmental Pollution One important result of the rapid growth of the human population and technology has been a substantial increase in the amount of environmental pollution.	Discuss the interaction of growth rate with ecological and economic concerns.
Many substances become pollutants when their presence exceeds the capacity of natural systems to break them down, or they cannot be broken down, or they are toxic.	Collect and discuss news articles about pollution of a local site or one of national or statewide interest.
1. Water pollution Water pollution interferes with our ability to obtain pure water for drinking, washing, recreating, and industry. Water pollutants include: • Pesticides • Sewage • Heavy metals • Organic chemicals • Inorganic chemicals	*What impact does the human population have on the environment?* • Collect two samples of pond water. Observe life forms in both. Pollute one using a variety of substances (e. g., salt, detergent, oil, manure). Observe both samples after a week to see changes in the polluted sample. • Monitor air pollution around the school grounds by mounting greased slides outside and examining them with a microscope each week. Keep a record of relative pollution levels. • Collect rain water in a clean beaker and attempt to determine its pH using an indicator such as bromthymol blue, litmus, or a pH meter. • Visit or bring in "random samples" from a local landfill. Study samples and determine the types and quantities of waste materials.
2. Air pollution Air pollution interferes with our ability to obtain clean air for breathing and it may produce residues (such as acids) which are destructive to our buildings and machines. Air pollutants include: • Smoke, ash, and soot • Sulfur and nitrogen oxides • Organic vapors • Carbon dioxide from burning	Students should understand the differences between "organic" and "inorganic" chemicals. Careers: Health Technician Sewage Treatment Plant Technician Air Quality Control Technician Soil Scientist Discuss DDT in relation to food chains; discuss pros and cons of banning pesticides or herbicides.

UNDERSTANDINGS	ACTIVITIES AND TEACHER NOTES
3. Soil pollution Soil pollution interferes with our ability to obtain clean water from wells, reduces our enjoyment of recreational areas, and may kill soil decomposers important in the cycling of materials. Soil pollutants include: • Organic chemicals • Inorganic chemicals • Solid wastes • Pesticides	
B. Improving the Environment If population growth and environmental pollution are not curbed, they are very likely to become limiting factors for our species, as well as other species. It is essential that steps be taken to improve our environment.	Refer to the concept of population growth and limiting factors. Birth control, as a means of controlling human population growth, may be discussed at local option.
1. Education Each individual's understanding of the natural world and human interaction with it is an important step toward improving the environment. Education is one way of fostering improved attitudes toward the environment.	Relate the students' study of biology to this goal. Careers: Outdoor Education Instructor Science Teacher Conservation Officer Forester
2. Research Scientists are constantly at work to increase our understanding of the natural world. Public support for such research will further the goal of improving the environment.	*How can the environment be improved?* • Go on "field trips" to catalog (and collect for disposal) litter around the school grounds. • Participate as a class in recycling drives or the activities of local environmental organizations.
3. Laws Our governmental agencies have a responsibility toward environmental protection. Federal, state, and local laws which regulate the use of natural resources and the development of lands help to improve the quality of our environment by restricting some of the abuses of the past.	Some environmental laws include: • Freshwater Wetlands Act • Hazardous Waste Disposal Regulations • Air Pollution Control Laws • Returnable Container Law • State Environmental Quality Review (SEQR) Act
4. Conservation Conservation involves protection and maintenance of natural resources such as soil, water, wildlife, and open space. Whether fostered by a change in individual attitudes or by governmental laws, the conservation of the limited natural resources available to us is an action essential to survival of the environment.	Mention community recycling and individual conservation efforts as methods of achieving this. Teachers should illustrate soil, water, wildlife, and open space conservation with specific examples.